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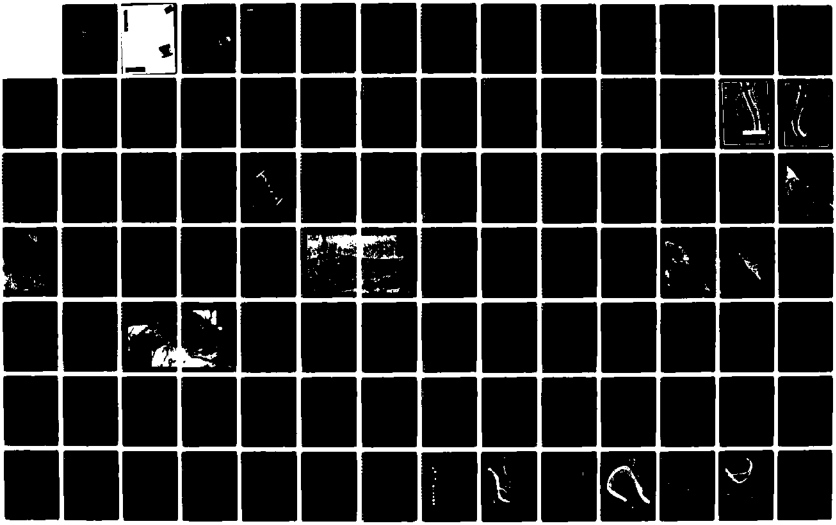

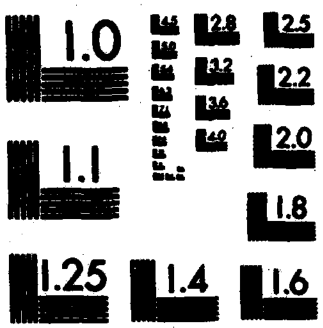

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The purpose of this study was to identify the type and quantity of aquatic habitats in the GREAT III reach, as well as the importance of these habitats to the fauna of the river throughout various life cycles and seasons.

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ESE ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

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May 14, 1982

Department of the Army
St. Louis District,
Army Corps of Engineers
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Attention: Mr. John Clark (EDC)

Subject: Final Report, GREAT III Ecological Characterization

Dear Mr. Clark:

ESE, Inc. is pleased to submit the Final Report for the GREAT III Ecological Characterization. Five copies and a camera-ready original have been provided to you, and 45 copies have been transmitted to the FWWG Chairman, Bill Ziegler. The report is contained in two volumes - the Primary Document and Appendices.

Do not hesitate to contact the office should you have questions. ESE anticipates that your office will provide written notification of contract completion in the near future.

Thank you.

Sincerely,

Brian P. Borof[illegible]
Project Director

BPB/mhs

cc: C. Franco
T. Hurlett
D. England
B. Ziegler

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EXECUTIVE SUMMARY

The purpose of the summary is to provide a thorough overview of the features, results, and conclusions of an aquatic habitat and biota study of the GREAT III reach of the Mississippi River. A detailed report presenting descriptions of habitats, sampling areas, and methods, and data follows the frontispiece.

1. The project study area encompassed all aquatic habitats within the floodplain (levee-to-levee or bluff-to-bluff) of the Mississippi River from Cairo, Illinois (River Mile 0) to Saverton, Missouri (River Mile 301). That portion of the study area from the Alton Lock and Dam (River Mile 201) to Saverton (River Mile 301) is termed the pooled river. The segment from Alton to Cairo (River Mile 0) is termed the open river.
2. The objectives of this study are twofold:
   a. to identify and define all aquatic habitat types within the study area based on physical, hydrological, and known or potential biotic parameters; and
   b. sample intensively each habitat with methods and effort sufficient to characterize the fauna of each habitat and to characterize the biotic significance of each.
3. A system was developed for identifying, defining, and delineating all aquatic habitat types within the study area, incorporating appropriate differences between the pooled and open river. The following habitat types were identified:
   a. main channel
      main channel border
   b. inside bend
   c. outside bend
   d. straight reach
      dike field
   e. stone dike

f. pile dike

g. side channel

h. slough

i. river lake
   littoral zone

j. natural littoral zone

k. revetted littoral zone

l. navigation pool

m. tailwater

n. mouth of tributary

o. downstream end of island

All of these habitats were sampled during field efforts.

For habitat mapping purposes only, the following habitats were utilized:

main channel
main channel borders
side channel
slough
river lake
navigation pool
tailwater
downstream end of island

4. Field data collection efforts were expended in all aquatic habitat types and at all four sampling areas during quarterly sampling periods; field sampling emphasized fisheries communities, but also involved collections of benthic invertebrates, mussels, and ichthyoplankton as well as qualitative observations of terrestrial fauna and herpetofauna.

   * Fisheries sampling was conducted using a combination of electrofishing, gill netting, trammel netting, hoop netting,

frame netting, otter trawling and seining; a special chemofishing sampling event was conducted at one side-channel location during low flow conditions.

* Benthic invertebrates were collected by ponar dredge, screened with #30 mesh sieve.
* Mussels were collected with a crowfoot brail.
* Ichthyoplankton samples were collected by metered net tows.
* Observations of non-aquatic fauna and herpetofauna were recorded during all aquatic sampling activities.

5. Benthic invertebrate collections (by Ponar dredge) suggested that the Oligochaeta (worms) and Diptera (flies) dominated the benthic invertebrate samples from nearly all soft substrates in all seasons.
   * Chironomidae represented the most abundant Diptera taxon; however, Ceratapogonidae also were common and widely distributed.
   * Ephemeroptera (mayflies) were common in many habitats, especially the genera Hexagenia and Pentagenia.
   * The following taxa were collected but were neither abundant nor widely distributed in most cases: Nematoda (roundworms), Hirudinea (leeches), Hydracarina (water mites), Isopoda (aquatic sow bugs), Collembola (springtails), Odonata (dragonflies, damselflies), Hemiptera (bugs), Trichoptera (caddisflies), Coleoptera (beetles), Gastropoda (snails), and Pelecypoda (mussels).
   * Other sampling methods (e.g. artificial substrates, sweepnetting) may yield a significantly different benthic composition more abundant in Trichoptera, Ephemeroptera, Odonata, Coleoptera, and Hemiptera.
6. Fish sampling efforts (quarterly) resulted in the collection of 22,574 fish comprising 69 taxa; 27,458 fish comprising 35 taxa were collected via chemofishing. Methods utilized and level of effort expended appear to be sufficient to categorize the fish communities of habitats sampled.

* The most abundant fish species encountered was the gizzard shad (*Dorosoma cepedianum*) which was collected in all habitats during all sampling periods. Carp (*Cyprinus carpio*) was second in overall abundance.
* Other abundant and widely distributed fish species included freshwater drum (*Aplodinotus grunniens*), emerald shiner (*Notropis atherinoides*), river shiner (*N. blennius*), channel catfish (*Ictalurus punctatus*), and shortnose gar (*Lepisosteus platostomus*). Field sampling was probably not initiated early enough to collect peak numbers of larvae of early spring spawners.

Ichthyoplankton sampling (quarterly only) resulted in the collection of 22 identifiable taxa throughout the study area. Abundant ichthyoplankters in the collections were *Dorosoma* spp. or *Alosa* spp., *Cyprinus carpio* or *Carassius auratus*, *Carpiodes* spp. or *Ictiobus* spp., *Stizostedion* spp. and *Aplodinotus grunniens*. Seasonal abundance varied with specific taxa throughout the study period. Densities were higher at the littoral areas (natural and revetted) than at the tailwaters, navigation pool, or main channel habitat. Field sampling was probably not initiated early enough to collect peak numbers of early spring spawners.

7. The limited sampling effort for mussels suggested that mussels were not common at any of the collection sites. Thirty-one mussels representing 11 species were collected during the study.
   * The most abundant species collected were *Amblema plicata*, *Quadrula quadrula*, and *Obovaria olivaria*.
   * The great majority of the mussels collected were taken from the pooled river (96.8 percent), with Winfield pool producing the highest catch (74.0 percent)
   * Mussels were collected at all habitats sampled, the majority collected from the dike field habitat (54.8 percent).
8. General faunal-habitat associations for both fish and benthic invertebrates (based on soft substrate sampling) indicate that

critical determining factors are current speed, substrate composition and stability, and quantity and quality of cover.

* Key habitats for benthic invertebrate density and diversity (based on soft substrate sampling) were found to be:
  - Pooled River - river lake, revetted littoral, slough, and side channel.
  - Open River - dike field (stone) and side channels.
* Key fishery habitats, in terms of diversity and catch-per-unit effort were found to be:
  - Pooled River - navigation pool, slough, river lake, dike field.
  - Open River - side channel, revetted and natural littoral

9. In terms of overall biotic characteristics, the following habitats are felt by the investigators to be of higher value in the GREAT III study area, based upon data collected and the resulting density and CPE, diversity, and taxonomic composition:

* Pooled River - river lake, slough, navigation pool, littoral
* Open River - side channel, dike field.

The above statement is not meant to diminish the biologic value of any habitat or to rank habitats, but is intended to identify those habitats which consistently are more productive of aquatic fauna and which serve key roles in faunal life histories. This identification is intended to provide inputs to river management processes and preliminary assessments of environmental impact.

1.0 INTRODUCTION

1.1 PURPOSE AND OBJECTIVES OF STUDY

In 1980, the St. Louis District of the Army Corps of Engineers (COE) contracted Environmental Science and Engineering, Inc. of St. Louis (ESE) to conduct an ecological characterization study of the Mississippi River from Saverton, Missouri to Cairo, Illinois, referred to herein as the GREAT (Great River Environmental Action Team) III reach. The GREAT III ecological characterization, as presented in this report, is one part of an extensive effort to collect and compile ecological data and information on the aquatic and aquatic-associated ecosystems of the upper Mississippi River.

The main goal of this research effort is to provide an extensive, current data base for development of a management plan on the multi-purpose utilization of river resources. These uses include recreation, commerce, water supply, and agriculture as well as aesthetic enjoyment. A secondary goal is to provide site-specific data which can be used to address questions concerning ecological impact of planned river development, dredging, construction, and related activities.

This specific study has two major objectives:

1. To identify, characterize, and quantify aquatic habitats in the GREAT III reach, and
2. To characterize the aquatic biota associated with each of the habitats identified.

The study incorporates several major tasks including 1) development of a habitat classification system, 2) habitat mapping, 3) extensive field data collection effort, and 4) an intensive literature review.

In addition to contract and study coordination provided by the St. Louis District COE, the Fish and Wildlife Work Group (FWWG) provided technical review and coordination of all elements of the study.

1.2 PURPOSE AND STRUCTURE OF REPORT

The primary purpose of this report is to summarize the habitat and aquatic biota information and data collected during this study. Habitats and specific sampling sites are described in detail. Habitat maps are presented in the text along with tabular presentations of habitat acreages.

Appendix A presents a general description of habitats based on field, map, and photo information. Results of field sampling are discussed in detail in the text. Appendix B contains additional benthos data, while Appendices C and D contain additional fisheries data.

The emphasis in the presentation of data is to show habitat associations of biota and to describe the biotic communities of various habitats. A general discussion of results is presented for the whole sampling area, individual sampling areas, and the pooled and open river segments.

2.0 HABITAT CLASSIFICATION SYSTEM

2.1 SYSTEM DEVELOPMENT

The major focus of the GREAT III Ecological Characterization is description and sampling of all aquatic habitats in the GREAT III reach. Definition and delineation of distinct habitats is a critical first step. Physical and hydrographic features, as well as potential biological criteria, were used to classify habitats.

In developing the Habitat Classification System (HCS), ESE employed several information sources and also drew on project personnel's familiarity and experience with midwestern aquatic systems. Sternberg's (1971) classification of habitats of the Upper Mississippi River formed the foundation for the HCS developed by ESE. The Sternberg system has been adopted by the Upper Mississippi River Basin Commission and the Upper Mississippi River Conservation Committee and is generally accepted by state and federal agencies working in the Upper Mississippi River system.

In addition to the Sternberg system, two other methods were evaluated but not substantially incorporated into the HCS (Shaw and Fredine, 1956; Cowardin et al. 1979). Both of these systems deal extensively with wetlands including marine, estuarine, and freshwater types. However, river systems are not analyzed in sufficient detail to fulfill the requirements of this project.

Aerial photographs, navigation maps, and earlier GREAT III base maps developed by the COE were consulted to determine the types and gradations of aquatic habitat present in the GREAT III reach. The U.S. Army Engineer Waterways Experiment Station (WES) and the St. Louis COE (as well Missouri DOC, IDOC, U.S.F.W.S.) have conducted or contracted a number of research and study efforts in Pools 24, 25, and 26 of the

Upper Mississippi and Lower Illinois Rivers (Dunham, 1971; Bertrand & Lockart, 1973; Bertrand & Garver, 1973; Bertrand & Allen, 1973; Robinson, 1972; Sparks _et al_., 1979; Colbert _et al_., 1974; Emge _et al_., 1974; Solomon _et al_., 1974; Yarbrough and Hensley, 1980; Hagen _et al_., 1977). These studies utilized habitat classification systems similar to those of Sternberg and the system utilized in this study.

Habitat delineations and biotic associations determined in these studies were reviewed in the development of the HCS.

The goals of developing the HCS were to:

1. Delineate areas having significant differences in physical and hydrologic parameters, and
2. Delineate habitat types which have significant biotic differences or the potential for such differences.

2.2 SYSTEM DESCRIPTION

The habitat classification system developed for this study is described in Table 2.2-1. Hypothetical pooled and open river segments are displayed in Figures 2.2-1 and 2.2-2; please note that symbols in these figures do not necessarily match those used in the formal habitat maps. Although a majority of the habitat types are found throughout the GREAT III reach, the pooled segment (Saverton to Alton) is more diverse in habitats than is the open river segment (Alton to Cairo), due to the impoundment of waters. To reflect the differences, separate systems were developed for the pooled and open segments.

The habitat classification system was used for mapping purposes as well as for field sampling. Delineation in field situations was not necessarily as clear-cut as in habitat mapping. The following sections describe the habitat types which were developed.

MAIN CHANNEL

The main channel is defined as the channel maintained for navigation purposes and extending shoreward to the distal ends of dike fields, when dike fields (three or more dikes within 1 mile) are present. At minimum the main channel is 400 feet wide by 9 feet deep. Maximum width approaches 800 feet with maximum depths of 45 to 55 feet recorded during the study. Main channel characteristics vary from riverine (lotic) to nearly lentic depending upon proximity and location relative to navigation dams.

MAIN CHANNEL BORDER

The main channel border is that area between the boundary of the main channel and the littoral zone, where dike fields are not present. Three distinct main channel border habitat types were differentiated based on significant differences in substrate and current conditions: straight

Table 2.2-1. Habitat Types Utilized in the Habitat Classification System for the GREAT III Reach

Habitat Type	Location
Tailwaters	Pooled River
Navigation Pool	Pooled River
River Lake or Pond	Pooled River
Slough	Pooled River
Downstream end of Island	Pooled River
Dike Field	Pooled River
Main Channel	Open and Pooled River
Main Channel Border - Inside Bend	Open and Pooled River
Main Channel Border - Outside Bend	Open and Pooled River
Main Channel Border - Straight Stretch	Open and Pooled River
Side Channel	Open and Pooled River
Natural Littoral Area	Open and Pooled River
Revetted Littoral Area	Open and Pooled River
Pile Dike	Open River
Stone Dike	Open River
Mouth of Tributary	Open River

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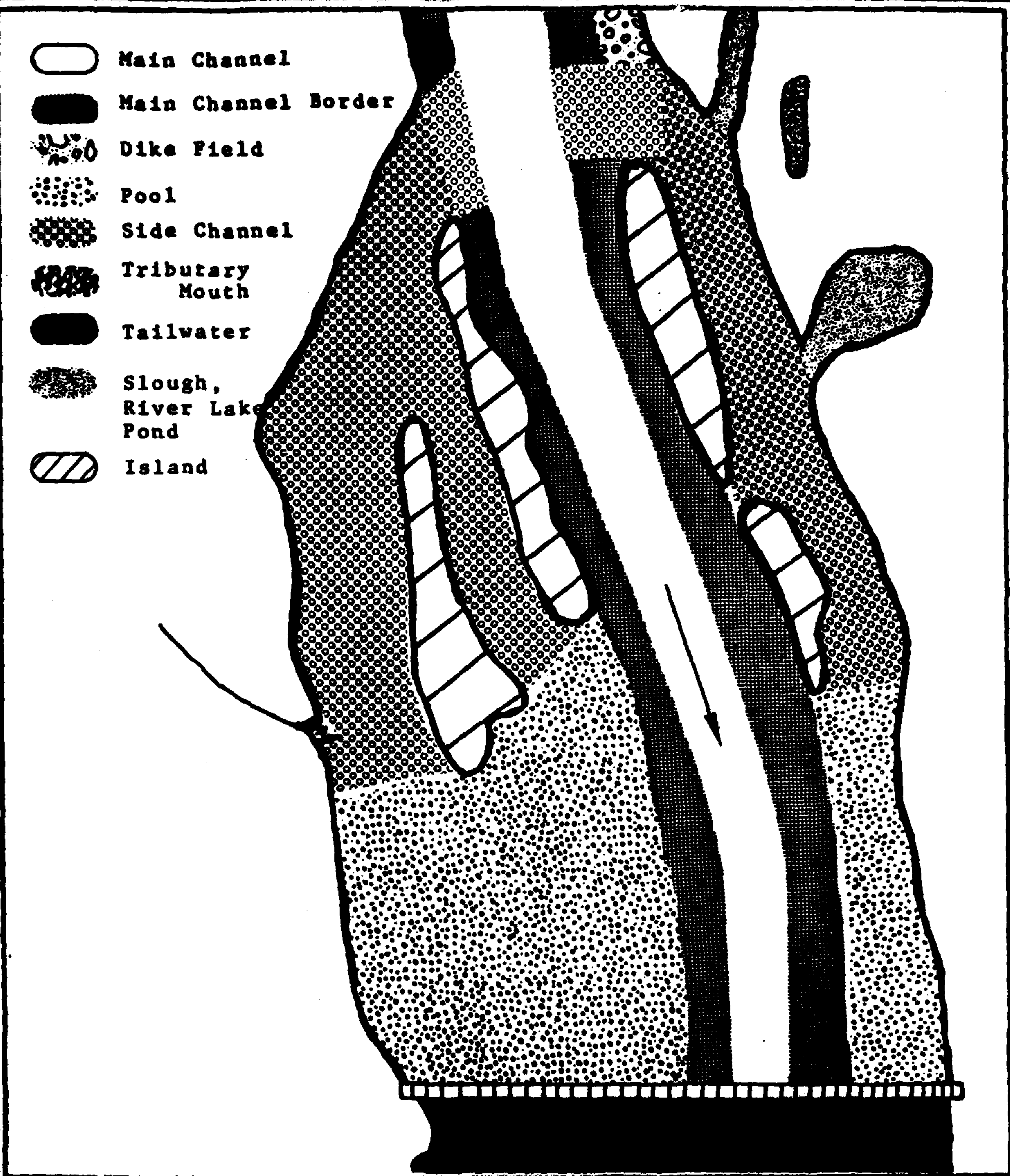

FIGURE 2.2-1

SCHEMATIC DIAGRAM OF HABITATS IN POOLED PORTION OF GREAT III REACH

SOURCE: ESE, 1982

GREAT III ECOLOGICAL CHARACTERIZATION STUDY

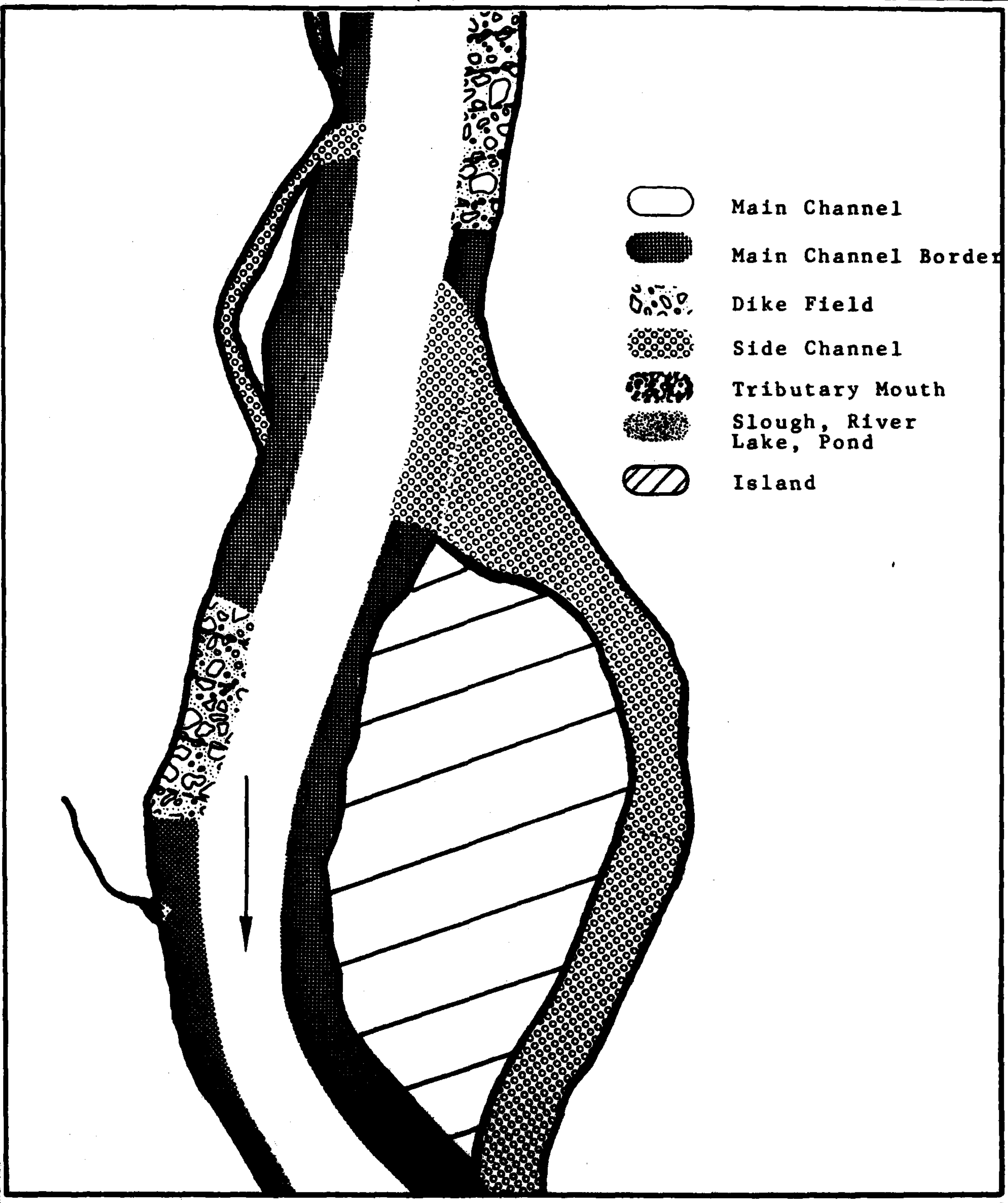

FIGURE 2.2-2

SCHEMATIC DIAGRAM OF HABITATS IN OPEN RIVER PORTION OF GREAT III REACH

SOURCE: ESE, 1982.

GREAT III ECOLOGICAL CHARACTERIZATION STUDY

reach, inside of bend, and outside of bend. A bend is defined as a change in angle greater than 20° within any 1-mile stretch of the river.

In field situations, it was not always possible to identify an extensive reach of main channel border free of dikes, especially in the open river. In these situations, main channel border sampling was conducted as far from dikes as possible in areas with the lowest concentration of dikes.

DIKE FIELDS

Dike fields are defined as that area encompassed by three or more dikes in proximity (within 1 mile). The riverward boundary is the distal ends of the dikes while the landward boundary is the shore, including any and all littoral areas. The upstream and downstream extent is arbitrarily defined as equal to half the length of the dikes.

LITTORAL ZONE

By classical definition, the littoral zone is defined as the zone of rooted aquatic vegetation or the zone of light penetration (Ruttner, 1953). Neither definition applies accurately to the Mississippi River, but the shallow streambank areas are of sufficient biotic value to merit delineation as a distinct habitat type. In this study, the littoral zone is defined as that area extending 25 feet from the water's edge during any sampling period. Revetted littoral and natural littoral zones are considered distinct habitat types due to differences in substrates and cover characteristics.

SIDE CHANNEL

The side channel habitat type is defined as a departure from the main body of the river having two points of connection (during average flow conditions) with the main river. Side channels generally flow behind islands and dredge spoil areas. Side channels are often referred to as chutes in the literature and on maps and charts. They generally have flowing water during the majority of the year.

SLOUGH

Sloughs are departures from the main body of the river, but differ from side channels by having only one connection with the main river. Consequently, there is minimal flow through the slough except during periods of high river discharge or rapid changes in river water levels. In the open river there are not enough sloughs to merit distinction as a habitat type. Therefore, sloughs are differentiated only for the pooled river segment.

RIVER LAKE

River lakes are lentic waters completely cut off from the main river but occurring on the present or former floodplain. There are a number of river lakes remaining within GREAT III, but they are restricted to the pooled river segment. Other former floodplain lakes occur in both the pooled and open river segments, but they are not within the leveed area and are not of concern in this study.

NAVIGATION POOL

The navigation pool is defined as that area impounded by the locks and dams constructed in the pooled segment of the river. By definition, the pool extends upstream to the point where the natural (pre-impoundment) channel is regained.

TAILWATER

The tailwater habitat type is also found only in the pooled river segment. It is that area extending for one-half mile below the locks and dams and encompassing the full width of the river.

TRIBUTARY MOUTH

This habitat encompasses the area where a tributary stream flows into the river. Arbitrary boundaries were defined such that the habitat area covers the tributary mouth and extends out into the river and back into the stream a distance equal to the width of the tributary.

DOWNSTREAM END OF ISLAND

This habitat encompasses the shallow water zone bordering the downstream end of larger islands. No firm boundary was established; in general, the habitat is that zone of reduced current and shallow waters and often exhibits slough-like characteristics.

3.0 STUDY AREA

3.1 DESCRIPTION OF THE GREAT III REACH

The GREAT III portion of the Mississippi River (Figure 3.1-1) is that segment from Saverton, Missouri (River Mile 301) to Cairo, Illinois (River Mile 0). The reach above River Mile 201 consists of a series of pools created by impoundment for navigation purposes. Below Mile 201 the river is not impounded, although most of it has been influenced by other navigation and channel control structures such as closing dams, dike fields, and bank stabilization controls.

The Mississippi River is a highly variable and complex aquatic system that is difficult to characterize. A more detailed description of specific sampling areas follows in Section 3.3.

The Mississippi River (above Cairo) and its major tributary, the Missouri River, drain areas of the Upper Midwest and Eastern Great Plains. The drainage area at St. Louis is 1,805,000 km^2 (USGS, 1979). The Mississippi carries consistently large volumes of water, averaging 5,013 m^3/sec. Maximum volumes of 28,900 m^3/sec and minimum volumes of 510 m^3/sec have been recorded at St. Louis (USGS, 1979). Seasonal changes in water levels and flow reflect precipitation and climatic conditions over large land areas. High flow and water level conditions occur most often in spring and early summer with lesser peaks in fall. Low water conditions are usually associated with dry (or cold) weather periods of summer and winter.

Major tributaries (in terms of potential influence on the Mississippi River) to the GREAT III reach include the Salt River, Cuivre River, Illinois River, Missouri River, Meramec River, Kaskaskia River, Marys River, Big Muddy River, and Ohio River.

FIGURE 3.1-1
LOCATION OF SAMPLING SITES
WITHIN THE GREAT III STUDY REACH
SOURCE: ESE, 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Table 3.1-1 lists significant tributaries and their river mile of confluence with the Mississippi.

Overall water quality of the GREAT III reach is determined by three primary factors:

1. The largest portion of the watershed is used for agriculture, resulting in large inputs of soil, sediments, organic nutrients, and agricultural chemicals.
2. The St. Louis Metropolitan Area and, to a lesser extent, other municipalities contribute large quantities of municipal, industrial, and stormwater inputs to the river.
3. The Missouri River substantially increases flow in the Mississippi River and contributes significant inputs of soil, sediments, nutrients, and other chemicals and increases Mississippi River turbidity downstream.

Habitat characteristics are determined by a number of factors, including:

1. Hydrologic characteristics of volume, depth, and current speed;
2. Substrate and cover characteristics;
3. Floodplain development;
4. Structural changes induced by manmade activities; and
5. Other man-induced impacts such as channelization, dredging, and overall water quality impacts.

The GREAT III reach provides a diversity of aquatic habitats, demonstrated by the Habitat Classification System developed for this study (Section 2.2). Historically, habitat acreage and diversity has been reduced in GREAT III due to a combination of changes relevant to the above factors. Non-main river habitats (river lakes, side channels, sloughs) have been especially reduced due to sedimentation, encroachment upon floodplain areas, and extensive structural and nonstructural

Table 3.1-1. Major Tributaries* and Their River Mile of Confluence Within the GREAT III Reach

Tributary	River Mile of Confluence
Salt River	285
Cuivre River	235
Illinois River	218
Missouri River	195
Meramec River	160.5
Kaskaskia River	117.5
Marys River	106.5
Big Muddy River	75.5
Ohio River	0.0

* Major tributaries were qualitatively selected based on their potential influence upon the Mississippi River.

Source: ESE, 1982.

modifications such as dikes, levees, channelization, and dredging (Sparks et al., 1979; Johnson et al., 1974). The degradation of the main channel bed may also contribute to reductions in extra-channel habitat (Simons et al., 1974, 1981a-e).

Habitat acreage and diversity are generally greater in the pooled portion than in the open portion. This is due largely to the impoundment of water behind navigation dams built in the late 1930's and early 1940's, causing inundation of former terrestrial habitats and creation of numerous backwater habitats. The open river has lost habitat due to constriction of flow and limitations on natural processes via channel regulating structures and maintenance activities.

3.2 METHODOLOGY OF SITE SELECTION

In order to select representative but feasible areas for field sampling purposes, several criteria were developed:

1. Each sampling area contains all necessary habitat types in representative form,
2. All sampling areas are relatively free from significant water quality degradation and unrepresentative water quality conditions,
3. Sampling areas must be well-distributed throughout the GREAT III reach, and
4. Logistics and size of sampling area must allow feasible access to, and sampling of, each area within the proposed time periods.

Using the above criteria and information obtained from aerial photographs, literature sources, and site reconnaissance, a number of potential sampling areas were proposed to the Fish and Wildlife Work Group (FWWG). Four sampling areas were selected--two in the pooled river segment and two in the open river segment. A detailed description of each sampling area is presented in Section 3.3.

3.3 DESCRIPTION OF STUDY SITES AND SAMPLING AREAS (HABITATS)

Based on the criteria listed earlier, two areas within the pooled portion of the river (above Lock and Dam 26) and two areas within the open river portion of the study area (below Lock and Dam 26) were selected as representative study sites for the GREAT III reach of the Mississippi River (River Mile 0 at Cairo, Illinois to River Mile 301.2 at Saverton, Missouri).

Selected study sites were:

1. Site 1--Clarksville Pool (24), Mississippi River Miles 273 through 282,
2. Site 2--Winfield Pool (25), Mississippi River Miles 241 through 253,
3. Site 3--Ste. Genevieve, Mississippi River Miles 115 through 132, and
4. Site 4--Cape Girardeau, Mississippi River Miles 50 through 63 (Figure 3.3-1).

All available habitat types were located and studied within each study site. Thirteen distinct habitat types were located in the pooled portion and ten distinct habitat types were located in the open river portion of the study area (Table 3.3-1). Generalized descriptions of the habitats sampled are presented in Tables 3.3-2 and 3.3-3. Specific habitat descriptions follow in the succeeding paragraphs. References to current velocities have been derived from literature sources and qualitative estimates, taken at different times and river conditions.

SAMPLING SITE 1

Sampling Site 1, the Clarksville Pool (24) was the northernmost sampling site during the investigations. Sampling at Clarksville was limited to the area between Mississippi River Miles 273 through 282. This 9-mile area included all 13 pooled river habitat types. The specific habitats selected for sampling at the Clarksville site are presented in Figure 3.3-2.

Table 3.3-1. Habitat Types and Station Numbers for Biological Sampling at the Pooled River and Open River Portions of the GREAT III Reach

Station No.	Habitat Type	Location
1	Tailwaters	Pooled River
2	Navigation Pool	Pooled River
3	River Lake or Pond	Pooled River
4	Slough	Pooled River
5	Downstream end of Island	Pooled River
6	Dike Field	Pooled River
7	Main Channel	Open and Pooled River
8	Main Channel Border - Inside Bend	Open and Pooled River
9	Main Channel Border - Outside Bend	Open and Pooled River
10	Main Channel Border - Straight Stretch	Open and Pooled River
11	Side Channel	Open and Pooled River
12	Natural Littoral Area	Open and Pooled River
13	Revetted Littoral Area	Open and Pooled River
14	Pile Dike	Open River
15	Stone Dike	Open River
16	Mouth of Tributary	Open River

Source: ESE, 1982.

Table 3.3-2. Generalized Descriptions of Habitat Features in the Pooled River Segment, *GREAT III* Reach

Habitat	Depth	Width	Current*	Substrates Features	Cover
Main Channel	3 - 9m	125 - 250m 410 - 820 ft.	0.7 - 4.5 fps	Sand-gravel	Typically none; Occasional stump or snag
Main Channel Border	1 - 8m	150 - 460m 492 - 1509 ft.	0.1 - 3.8 fps	Silt, with some gravel, sand, clay, detritus	Stumps, snags, logs
Side Channel	1 - 5 m	60 - 900m 197 - 2953 ft.	0.2 - 1.4 fps	Silt-mud, some sand, scour holes, undercut banks	Stumps, snags, logs, vegetation
Slough	<1m	Variable; size 0.25 - 100 acres	Typically none	Soft silt-mud, detritus	Logs, stumps, vegetation
River Lake	<1 - 3m	Variable; size 0.5 - 100 acres	Typically none	Soft silt-mud, detritus	Vegetation
Navigation Pool	<1 - 5m	600 - 1,200m 1969 - 3937 ft.	Variable; Typically none near shore to 2.5 fps near lock and dam	Silt-mud, scour holes, mud bars	Stumps, some vegetation
Tailwater	1 - 9m	600m 1969 ft.	0.5 - 5.0 fps	Rock, sand, gravel some silt, scour holes	Stumps, logs
Dike Fields	1 - 6m	40 - 80m 131 - 262 ft.	0 - 3.1 fps	Variable; silt, sand, rock riprap, sand bars, mud bars, scour holes	Logs, snags
Downstream-End-of-Island	<1 - 3m	30 - 200m 98 - 656 ft.	0 - 3.0	Silt-mud; sand, mud bars, sand bars	Stumps, logs, vegetation
N[illegible]ral Littoral	<3m	6 - 8m 20 - 26 ft.	0.2 - 2.5	Silt; some mud and sand, undercut banks, scour holes	Snags, stumps, logs
Revetted Littoral	2 - 6m	6 - 8m 20 - 26 ft.	0.5 - 3.0	Rock riprap, some silt, sand, scour holes	Some vegetation

* Schramm and Lewis, 1974; Colbert et al., 1974; and general observations and projections.

Source: ESE, 1982.

Table 3.3-3. Generalized Descriptions of Habitat Features in the Open River Segment, GREAT III Reach

Habitat	Depth	Width	Current*	Substrates/ Features	Cover
Main Channel	5 - 17m	125 - 150m 410 - 492 ft.	3.0 - 6.0	Sand-gravel	Typically none
Main Channel Border-Inside	<1 - 5m	50 - 250m 164 - 820 ft.	1.0 - 3.0	Silt-sand	Snags, logs
Main Channel Border-Outside	1 - 6m	75 - 125m 246 - 410 ft.	3.0 - 6.0	Silt-sand, some rock riprap	Snags, logs
Main Channel Border-Straight	1 - 6m	50 - 100m, 164 - 328 ft.	2.0 - 5.0	Silt-clay; some sand, and rock riprap	Snags, logs
Side Channel	<1 - >50m	60 - 200m 197 - 262 ft.	0.2 - 1.5	Silt-sand, undercut banks, scour holes, mud bars, sand bars	Snags, logs, vegetation
Stone Dike	<1 - 6m	40 - 80m 131 - 262 ft.	0 - 4.5	Variable; silt and sand; rock riprap, mud bars, sand bars, scour holes	Snags, logs
Pile Dike	<1 - 4m	20 - 60m 66 - 197 ft.	0 - 2.5	Silt-sand; wood piles, scour holes, mud bars	Snags, logs
Tributary Mouth	<1 - 5m	30 - 300m 98 - 984 ft.	0.2 - 2.0	Silt-sand, some detritus, sand bars, mud bars	Snags, logs, some vegetation
Natural Littoral	6 - 8m	<3m (<10 ft.)	0.3 - 3.0	Silt-sand, some detritus, undercut banks, scour holes	Snags, logs, some vegetation
Revetted Littoral	6 - 8m	<5m (<10 ft.)	0.5 - 3.5	Rock riprap, scour holes	Typically none

* Schramm and Lewis, 1974; Colbert et al., 1974; and general observations and projections.

Source: ESE, 1982.

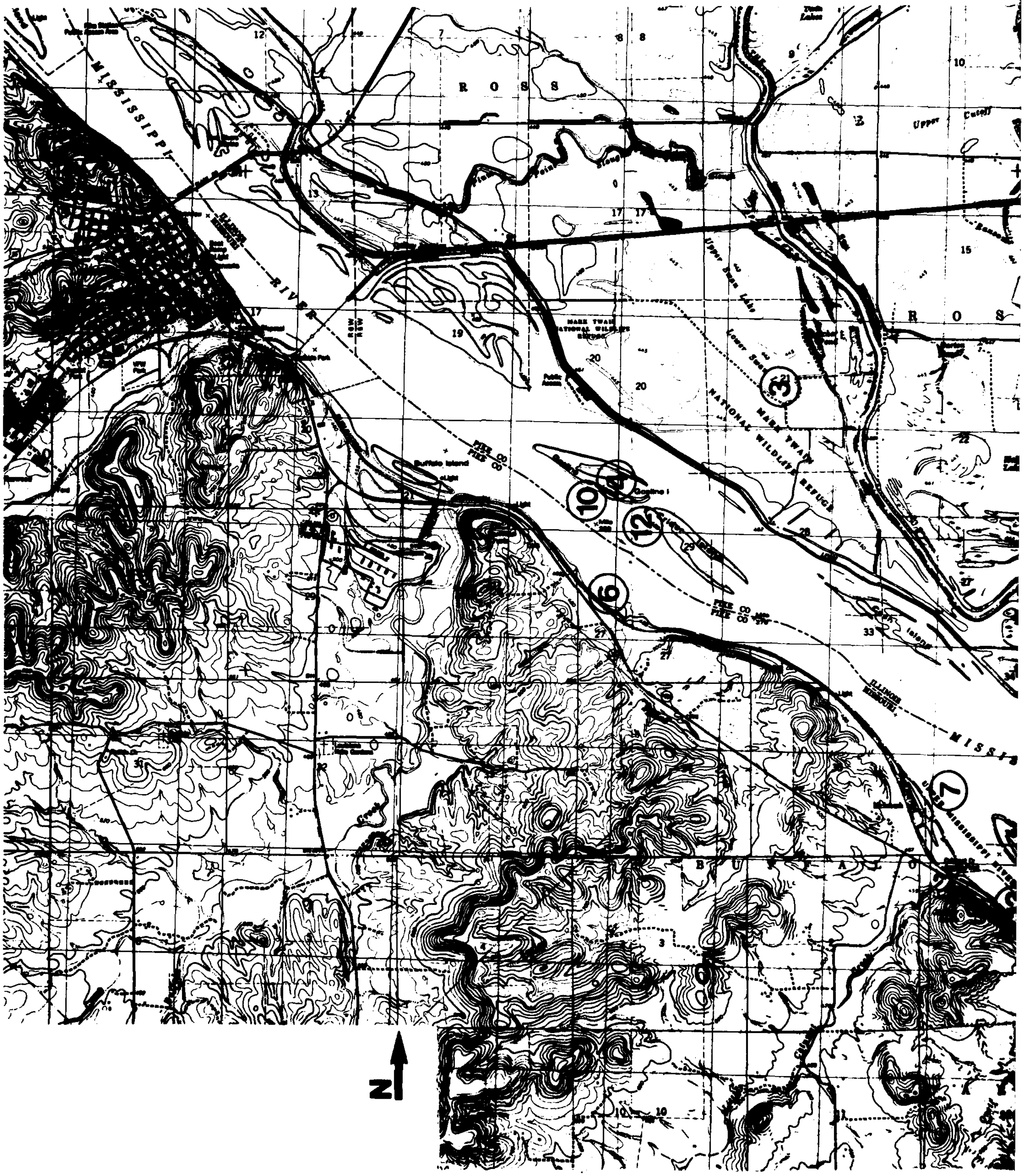
MISSISSIPPI
RIVER
ROSS
MARK TWAIN NATIONAL WILDLIFE REFUGE
PIKE CO
ILLINOIS
MISSOURI
Upper Cutoff
Buffalo Island
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FIGURE 3.3-2

SAMPLING SITE 1 -
CLARKSVILLE POOL (24)
MISSISSIPPI RIVER MILES 273 - 282

SOURCE: ESE. 1982

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The Clarksville Pool was formed in 1940 as part of the development of the nine-foot deep navigation channel as authorized in the River and Harbors Act of 1930. The Clarksville pool is approximately 27.8 river miles in length. The Clarksville Pool contains numerous islands and associated side channels. Many of these areas were formed after the construction of Lock and Dam 24 (Simons et al. 1975). The majority of the islands and side channels are in the northern and middle portion of the pool. The specific study area contains about six islands. River lakes and ponds are also abundant in the Clarksville Pool, especially on the Illinois side of the river (Figure 3.3-2).

Specific habitats studied at the Clarksville site are described in the following sections.

Station 1--Tailwaters of Lock and Dam 24

The Tailwater Area, as defined in this study, includes the 1/2-mile of river immediately below the lock and dam. This area at Clarksville (River Mile 273L) is turbulent for a distance of approximately 400 yards below the dam due to the water pouring through the dam. The shoreline in the area is entirely revetted on the Illinois river bank and sporadically revetted on the Missouri bank. The Six Mile Creek diversion ditch enters the river immediately below the dam and provides some slackwater habitat. Depths are variable throughout the tailwater area with mid-river depths typically 15 to 35 feet deep and near-shore areas 5 to 20 feet in depth. Currents are swift throughout the area.

Station 2--Navigation Pool

The Navigation Pool at Clarksville is located predominantly on the Illinois side of the river near River Mile 273.3. Within the slack current portion of the navigation pool, the banks are revetted along the southeast bank and bare on the remaining banks. Water depth is 2 to 6 feet with numerous stumps scattered throughout the area. Bottom sediments are silt, mud, and detritus. Swifter currents and deeper

water (10 to 15 feet) are located in the pool near the channel border areas and the lock and dam.

Station 3--River Lakes and Ponds

Lower Swan Lake, located in the Mark Twain National Wildlife Refuge, was selected for the Clarksville River Lake sampling station. This lake is approximately 60 acres in size, highly eutrophic and apparently undergoing rapid sedimentation. Subsequently, lower Swan Lake is uniformly shallow (2 feet) and has a deep silt and detritus bottom. Shoreline vegetation is abundant and is dominated by cattails (*Typha* spp.).

Station 4--Sloughs

Slough areas within the Clarksville study site are limited to shallow sections associated with the major islands. These areas are not common in the pool and are generally very shallow (<2 feet). The sloughs within the area are also heavily covered with emergent rooted aquatic vegetation dominated by American lotus (*Nelumbo lutea*). Other common plants include water primrose (*Jussiaea* spp.) and naiad (*Najas* spp.). Most sloughs in the Clarksville area are covered entirely with plant growth. In a few locations, the central areas of the slough are free of vegetation. Bottom substrates of sand or detritus, silt, and mud are present. Slough areas are typically small, not exceeding 10 acres (approximately) in size. Sampling was accomplished near Gosline Island at River Mile 280L.

Station 5--Downstream End of Island

This habitat in the Clarksville site is similar at all locations. The specific sampling location for the study is located downstream of Middleton Island near River Mile 274.5L (Figure 3.3-2). This, and all other downstream island habitats, are characterized by firm sand bottoms, which gently slope from water depths of about 6 inches near shore to about 6 feet at 300 yards from shore. The current is moderate in this area due to the buffering effects of the island.

Station 6--Dike Field

The Dike Field selected for sampling at Clarksville is located near River Mile 280 along the Missouri bank of the river south of Gosline and Crider Islands. Spring Creek enters the river at the dike field, approximately bisecting the area. The dikes in the area are not visible even during low-flow periods. Currents are variable and numerous tree snags are present. Bottom sediments are mostly mud, silt, and detritus.

Station 7--Main Channel

The main channel sampled in the Clarksville Pool is located near River Mile 277 between Pharrs Island and the Missouri bank.

Station 8--Inside Bend of Main Channel Border

The main channel border habitat selected for study is located near River Mile 277R along an inside bend next to Pharrs Island (Figure 3.3-2). The area is characterized by a reduced current (compared to the main channel), soft substrates (mud, detritus, etc.) and a few log snags. The southern half of the area also has a variety of shallow water vegetation along the bank, dominated by *Typha* spp.

Station 9--Outside Bend of Main Channel Border

The outside bend habitat sampled is located immediately opposite the inside bend near River Mile 277R (Figure 3.3-2) The bank along this area is revetted and steeply sloped. Currents are generally swifter than those of the inside bend and water depths range from 10 to 25 feet. Rock, sand, and mud substrates are typical of the area.

Station 10--Straight Stretch of the Main Channel Border

Sampling for this station took place adjacent to Gosline and Crider Islands near River Mile 280. Some log snags are present in the area, with currents and substrates similar to those of the inside bend.

Station 11--Side Channel

Biological data collections were undertaken at the side channel between Pharrs Island and an unnamed island to the north near River Mile 277 (Figure 3.3-2). The banks are lined with a variety of aquatic vegetation and some log snags. The bottom composition is mostly sand and the bottom configuration generally uniform. Depth ranges between 8 to 13 feet.

Station 12--Natural Littoral

Numerous natural littoral areas occur in the Clarksville study area. The area selected for sampling is located adjacent to Gosline and Crider Islands near River Mile 280. Numerous fallen trees and snags are located within the area. Bottom composition is mud and sand. Water depth frequently varies between 2 and 7 feet.

Station 13--Revetted Littoral

Revetted areas in the Clarksville Pool study area are limited to the Missouri bank just above Calumet Creek to Lock and Dam 24. Sampling was undertaken above and below Calumet Creek near River Mile 277.5R (Figure 3.3-2). The banks are steep in this area with a substrate composed of large boulders, mud, and sand. Depths of 3 to 9 feet are common throughout this area.

SAMPLING SITE 2

Sampling Site 2, the Winfield Pool (25) is located immediately downriver from the Clarksville Pool (24). Sampling at Winfield was limited to Mississippi River Miles 241 through 253. The Winfield Pool (formed in 1939) is 32 river miles in length, extending from Lock and Dam 24 at River Mile 273.4 to Lock and Dam 25 at River Mile 241.4. The 12-mile stretch selected for sampling contained all 13 pooled river habitat types (Figure 3.3-3).

The Winfield Pool is similar to the Clarksville Pool in that numerous islands and side channels are present throughout the pool. Many of

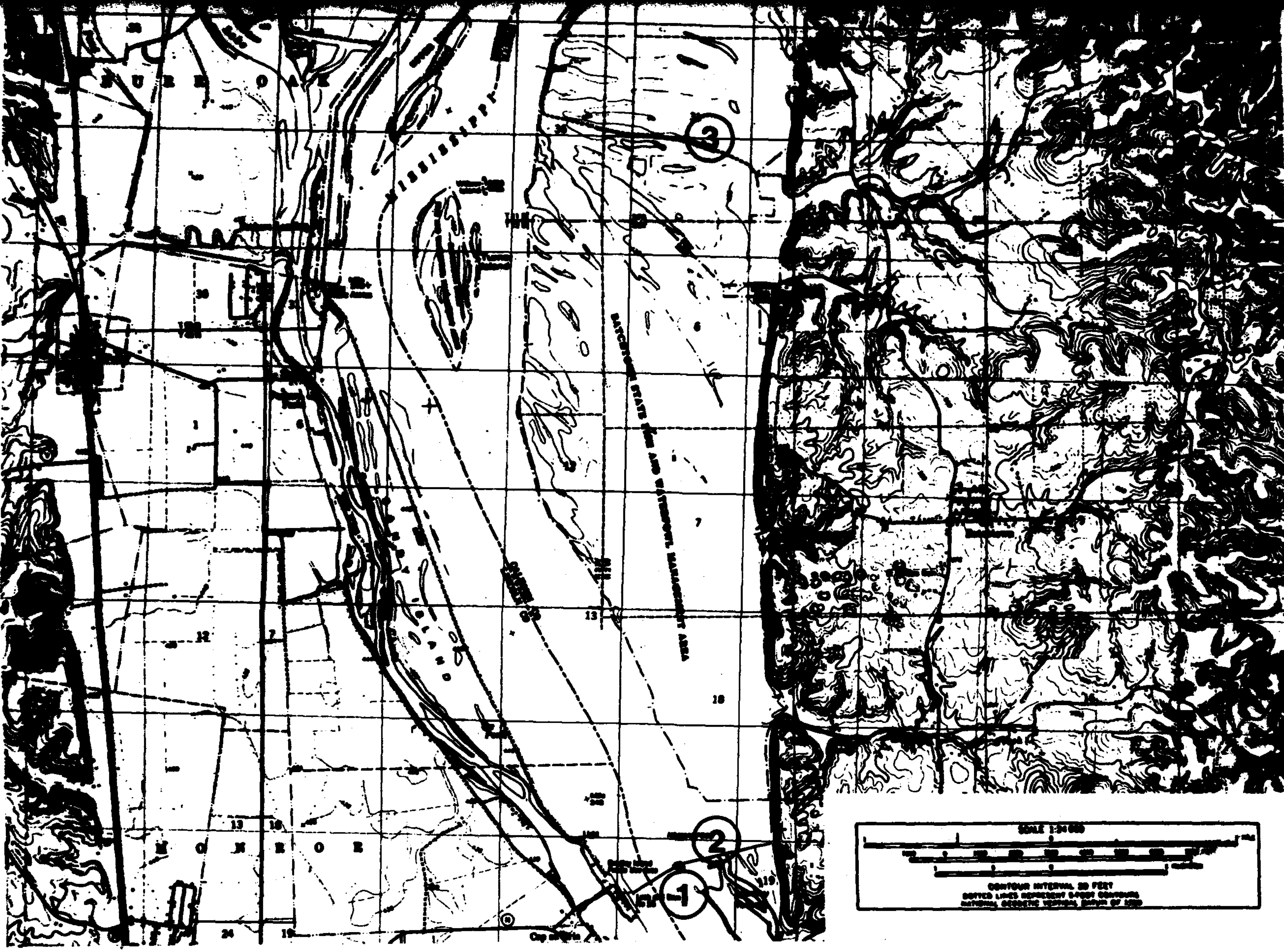

FIGURE 3.3-3
SAMPLING SITE 2 -
WINFIELD POOL (25)
MISSISSIPPI RIVER MILES 241 - 253

SOURCE: ESE, 1982

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these islands and side channels are close to the river banks, forming numerous slough and backwater areas. River lakes and ponds are abundant at the Winfield Pool site. The Missouri side of the river contains more river lakes than the Illinois side, although they are locally abundant throughout the sampling area (Figure 3.3-3).

Station 1--Tailwaters of Lock and Dam 25

The tailwater habitat at Winfield is similar to that at Clarksville. The water is turbulent and swift except for a small section of slackwater along Maxey Island. The area is revetted on the Illinois bank where near-shore biological sampling was undertaken. Water depths of 15 to 35 feet are common throughout the mid-river portions of the tailwaters while depths of 3 to 15 feet are typical closer to the banks. The area sampled is located near River Mile 241L.

Station 2--Navigation Pool

The Winfield navigation pool sampling area is located on the Illinois side of the river near River Mile 241.5L. As with the Clarksville Pool, this area has little current, water depth of 2 to 6 feet, and numerous scattered stumps throughout the area. Swifter currents and deeper water are located in the navigation pool near the lock and dam and the channel border.

Station 3--River Lakes and Ponds

The river lake selected for sampling at Winfield is located in the Batchtown State Fish and Wildlife Management Area (Figure 3.3-3). This lake and the area around it have changed since the 1975 topographic maps used in the study were made. The area shown on the map is now a series of small lakes separated by land and wetland areas. The lake selected for investigation is approximately the same size as Lower Swan Lake at Clarksville, but is deeper and not in the same eutrophic condition. The Winfield lake is approximately 4 feet in average depth. The lake contains numerous fallen trees and snags. Shoreline and emergent

vegetation is minimal throughout the lake. Bottom substrates are soft, composed primarily of mud, silt, and detritus.

Station 4--Sloughs

Two different slough areas were sampled due to water level fluctuations. The spring collections were made at a location near Titus Hollow (River Mile 245L). The remaining collections were made in Church Slough near River Mile 249L (Figure 3.3-3). Church Slough was not sampled in the spring due to high water levels. Titus Hollow was sampled only in the spring, after which time it was inaccessible due to low water levels.

The Church Slough sampling area is characteristically shallow (2 to 3 feet) with a variety of aquatic and semi-aquatic plants present. Bottom sediments are mud, silt, and detritus.

Station 5--Downstream End of Island

The sampling area selected is located on the Illinois side of the river on two islands adjacent to Sterling Island and Mud Slough near River Mile 252L (Figure 3.3-3). The area is characteristic of all downstream end of island areas in that the substrate is sand, the general topography is shallow (1 foot), gently sloping toward deeper water (10 feet), and the current speed is moderate. This area regularly receives dredged material, most recently in 1980 and 1981.

Station 6--Dike Field

Dike field biological sampling was undertaken between River Miles 250L and 251L (Figure 3.3-3). The dikes in the area are not visible even during low flow periods. Fallen trees and snags are not common. Bottom sediments are sand, mud, and silt.

Station 7--Main Channel

Main channel sampling took place between River Miles 250 and 251. Water depth ranges from 18 to 35 feet. The area is typical of main channel

areas throughout the pooled Mississippi River in the study reach. This area is dredged frequently, most recently in 1980.

Station 8--Inside Bend of Main Channel Border

The inside bend habitat selected for sampling is located along Stag Island (Figure 3.3-3) on the Illinois side of the river near River Mile 248.5R. The current is slower than that of the main channel, and cover, such as log snags or fallen trees, is uncommon. Bottom depths of 5 to 15 feet are found in the area. Soft bottom substrates typical of the reduced current are characteristic in this habitat. This area recently received dredged material (1973).

Station 9--Outside Bend of Main Channel Border

Outside bend samples were collected opposite the inside bend sampling area, adjacent to Maple Island near River Mile 248.5L (Figure 3.3-3). Shoreline features in the area consist of mud and sand bars. Water depth varies from 6 to 15 feet and currents are swifter than the inside bend. Log snags are uncommon. This site was dredged and received dredged material in 1973.

Station 10--Straight Stretch of Main Channel Border

The straight stretch channel border sampling station is located near the Illinois bank at River Mile 251 (Figure 3.3-3). The area is typically 5 to 12 feet deep. Current speed varies with river stage, but is generally much slower than main channel current. This site was dredged most recently in 1966.

Station 11--Side Channel

The side channel selected for sampling was located between Sterling Island and the Missouri bank near River Mile 251.3. The current varies between swift and slow depending on the specific location within the side channel. Fallen trees and log snags are common in the area. Water depth near shore is approximately 3 to 5 feet.

Station 12--Natural Littoral

Natural littoral areas are abundant at shoreline locations throughout the Winfield study area. The area selected for sampling is located along the Illinois bank near River Mile 252. Mud and sand banks, few fallen trees, moderate currents, and shallow depths (2 to 8 feet) characterize the area. This area received dredged material in 1980.

Station 13--Revetted Littoral

Revetted littoral areas are less abundant than natural littoral areas at the Winfield study site. Collection at the revetted littoral habitat was made along the shoreline of Sterling Island near River Mile 252 (Figure 3.3-3). The current along the revetted area is swifter than that of the natural littoral area. Habitat diversity is minimal, with large boulders composing the entire habitat along the island. Depths of 3 to 12 feet are found throughout the area.

SAMPLING SITE 3

Sampling Site 3 is the northernmost open river sampling location. The site is located near Ste. Genevieve, Missouri between Mississippi River Miles 115 and 132 (Figure 3.3-4). This 17-mile stretch of river includes all the open river habitats. The general area is characterized by swift currents, narrow river width, frequent barge traffic. Islands, side channels, and other backwater areas are uncommon in the Ste. Genevieve study area.

The following specific habitats were studied at the Ste. Genevieve sampling site.

Station 7--Main Channel

The main channel habitat sampling location is near River Mile 117, where the current is swift regardless of river stage. Water depths are typically 20 to 35 feet throughout the channel. This area is frequently dredged, most recently in 1981.


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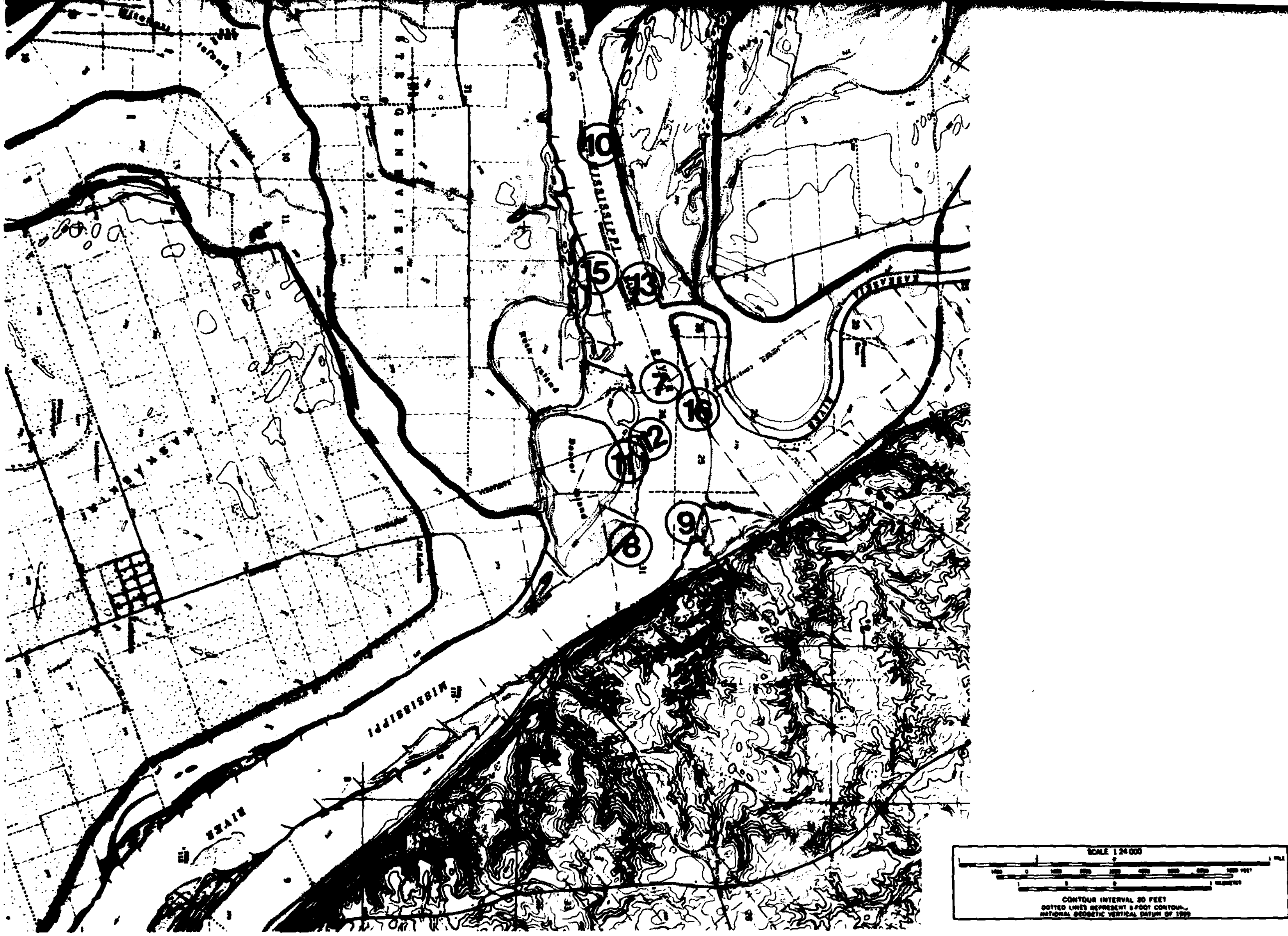

FIGURE 3.3-4

SAMPLING SITE 3 -
STE. GENEVIEVE
MISSISSIPPI RIVER MILES 114 - 127

SOURCE: ESE, 1982

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Station 8--Inside Bend of Main Channel Border

Samples for the inside bend channel border habitat were collected near Beaver Island at River Mile 116.5R (Figure 3.3-4). Current speed is less than the main channel areas, and sand and gravel substrates are common. Depths of 7 to 15 feet are also common in the area. This area most recently received dredged material in 1980 and 1981.

Station 9--Outside Bend of Main Channel Border

The outside bend habitat selected for sampling is located near the Illinois bank at River Mile 117. The area is partially revetted and two small creeks enter the river at the sampling area. Current velocities are swift regardless of river stage. Depths are typically 7 to 20 feet with a portion of the area about 5 feet deep due to a limestone ledge outcropping along the river bank. This area most recently received dredged material in 1977.

Station 10--Straight Stretch of Main Channel Border

The straight stretch habitat location selected for sampling is located at River Mile 119 along the Illinois side of the river. The bank is partially revetted at the site, with some log snags and generally swift currents typical in the area. Sand substrates are common; average depth is 10 to 15 feet. This site received dredged material in 1976.

Station 11--Side Channel

The majority of sampling took place at the Kaskaskia side channel located near Beaver Island at River Mile 117R. Mussel sampling was conducted at the Kaskaskia side channel and at Moro Chute, River Mile 120. The Kaskaskia side channel has variable water flow depending on river stage. The channel becomes cut off from the river during low river stages (St. Louis gauge 6 feet or lower). This area was the site for the rotenone collection portion of the study. The area typically has a mud, silt, and sand substrate with some fallen trees and log snags. The average depth in this side channel is about 4 feet with a few 20-foot deep holes.

Station 12--Natural Littoral

Natural littoral habitats are less abundant than modified areas (dike fields, revetted areas) at this site. Collections were made along the right bank of the inside bend at River Mile 117. The area has varying water depths due to sand bar deposition and a few fallen trees and log snags. Water depths in sampled areas are typically 3 to 6 feet. This area most recently received dredged material in 1980 and 1981.

Station 13--Revetted Littoral

Revetted littoral habitats are common at the Ste. Genevieve sampling site, and are typically located along the bank at outside bends. The area selected for sampling was located near River Mile 118 on the Illinois bank above the confluence of the Kaskaskia River (Figure 3.3-4). The area is characterized by sand and rock substrates, swift currents dependent on river stage, and low habitat diversity. River depths were variable at this habitat. Depths of 1 to 3 feet are typical immediately adjacent to the bank, while depths of 5 to 12 feet are typical 10 to 15 feet riverward of the bank.

Station 14--Pile Dike

Pile dike habitat is uncommon throughout the GREAT III segment of the Mississippi River. Many of the pile dikes which do exist are in a state of decay or have been incorporated into stone dikes. The pile dike habitat selected for investigation was limited to a few small dikes that have been partially modified by additions of large amounts of stone at River Mile 127R. This habitat has reduced current, mud and sand substrates (mud, silt deposition behind the dikes), and depths ranging from 1 to 10 feet. This area most recently received dredged material in 1979.

Station 15--Stone Dike

Stone dikes are common throughout the Ste. Genevieve site and are typically located along straight stretches or before and after bends in the river. The dikes are set perpendicular to the current and are

covered with large rocks and some concrete rubble. The stone dikes selected for sampling were located near River Mile 119 along the Missouri bank (Figure 3.3-4). Substrates vary from silt and mud near shore to sand and boulders at the dike tip. Counter currents and eddies are typical within the dike fields. Currents are swift at the dike tips, which are frequently submerged, and slack near the dam base. This area was spoiled most recently in 1977.

Station 16--Mouth of Tributary

Only one tributary mouth large enough to sample is located in the study area. This tributary, the Kaskaskia River, has been channelized with one lock and dam located near its juncture with the Mississippi River at River Mile 117.5L. The area sampled is variable in depth with the river stage and is composed of mud flats. Vegetation is sparse except for small willows (Salix spp.) which become inundated during high water, providing habitat diversity. Currents are generally slack throughout the area.

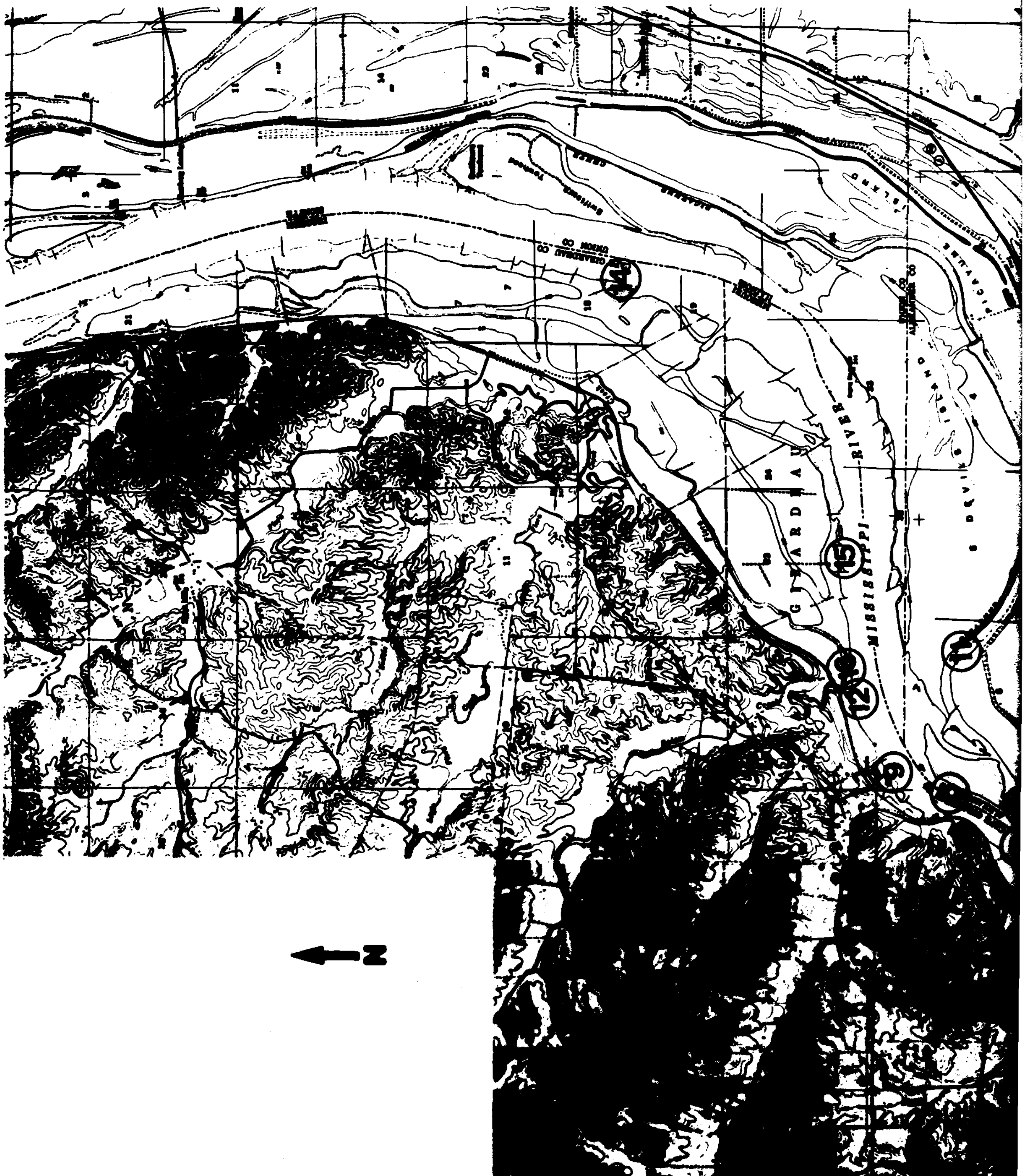
SAMPLING SITE 4

The river reach near Cape Girardeau, Missouri was the fourth sampling site. Collections encompassing all ten open river sampling habitats were made from River Miles 50 through 61 (Figure 3.3-5). Current velocities of the general sampling site are swifter than those at the Ste. Genevieve site. Other characteristics include heavy barge traffic, narrow river width, and some habitat diversity existing as natural littoral near small tributarities and larger side channel areas.

The following stations were studied at the Cape Girardeau site.

Station 7--Main Channel

The main channel at the study site is typically swift and narrow throughout the area. The specific sampling site is located near River Mile 54. Water depths of 20 to 35 feet are common. The main channel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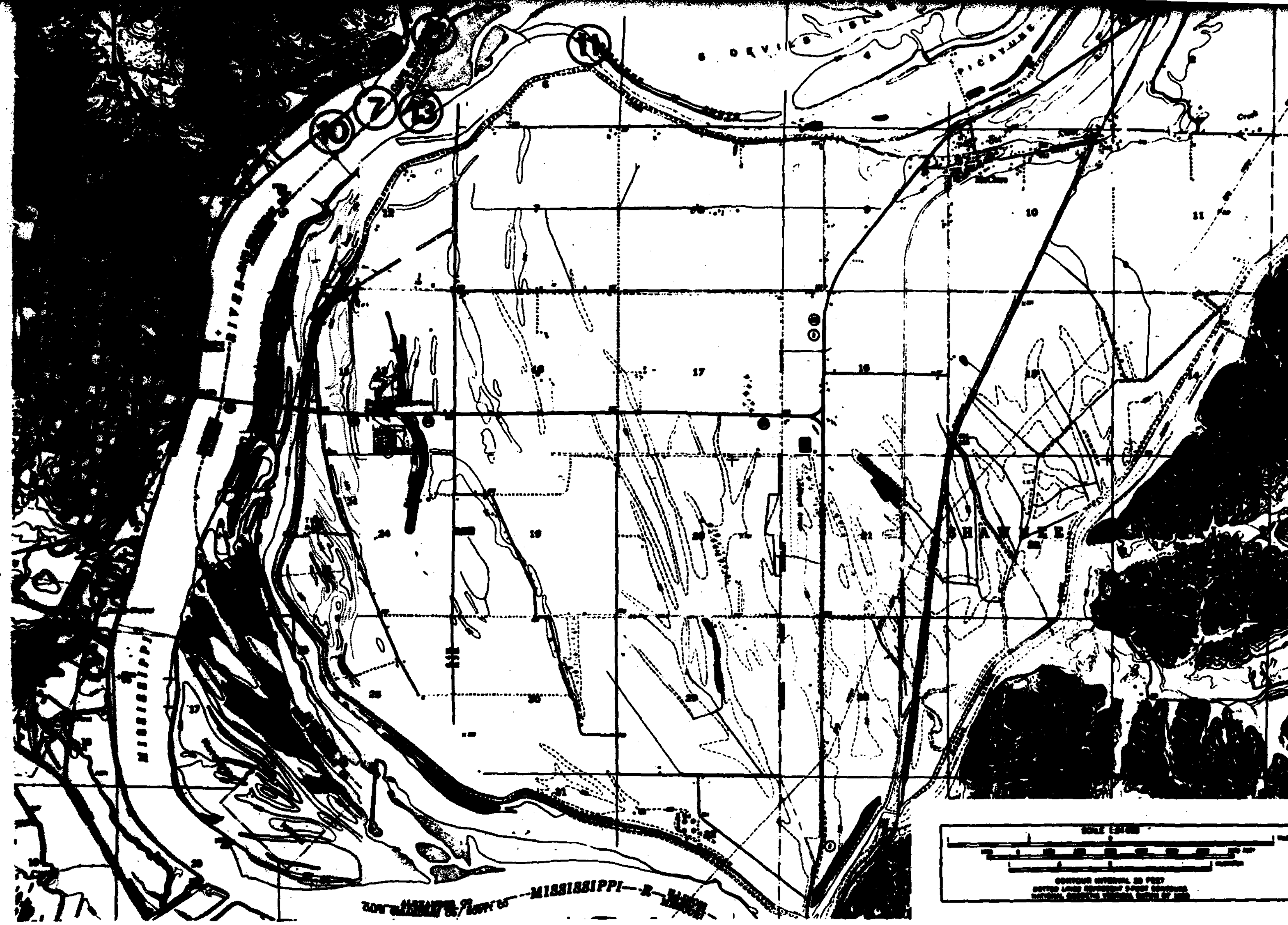

FIGURE 3.3-5

SAMPLING SITE 4 -
CAPE GIRARDEAU
MISSISSIPPI RIVER MILES 51 - 61

SOURCE: ESE, 1982

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width is approximately 600 feet throughout the sampling area. This area was dredged most recently in 1979.

Station 8--Inside Bend of the Main Channel Border

The specific habitat area selected for the inside bend channel border sampling is located above Picayune Chute near River Mile 55L. The shoreline in this area contains stone dikes and natural and revetted littoral areas. Currents are less than main channel velocities and habitat diversity in the form of log snags is not evident. Bottom substrates of mud and sand are typical of the area. This habitat is generally similar to the inside bend area sampled at Ste. Genevieve.

Station 9--Outside Bend of the Main Channel Border

Outside bend channel border collections were undertaken on the Missouri side of the river near River Mile 55. The current is swift throughout the area and, at the time of sampling, the current at the downstream end of the station was reversed for approximately 300 yards. Water depths are 10 to 30 feet, with variable substrate types including bedrock, gravel, sand, and mud. This area was dredged in 1979.

Station 10--Straight Stretch of Main Channel Border

Straight stretch channel border collections were made immediately downstream of the outside bend sampling area near River Mile 53.5R (Figure 3.3-5). Current velocity is less than that of the outside bend. Habitat diversity is minimal and no apparent log snags or other structures are visible in the area. The river bank at this station is revetted and bottom substrates are variable including rock, sand, and mud substrates. Typical depths are 6 to 18 feet. This site was dredged in 1970 and 1980.

Station 11--Side Channel

Side channel collections were made at the downstream portions of Picayune Chute, which opens at the river near River Mile 53.5L. Collections were made in the side channel upstream of a dike crossing

the entire chute and away from the main river influence. Water depths vary from 5 to 15 feet in most portions of the chute, except in the turbulent water area below the closing dike. Here, depths range from 15 to 50 feet. During sampling, large numbers of fish were found in the area immediately below the chute dike. Bottom substrates are typically mud, silt, and detritus. Current velocity is slight except near the dike. Habitat diversity is present in the forms of fallen trees, log snags, dike tailwaters, and zones of variable current.

Station 12--Natural Littoral

The abundance of natural littoral areas at the Cape Girardeau study site is similar to that of Ste. Genevieve in that natural littoral areas are less common than disturbed areas (revetted areas, dike areas). The natural littoral area collections were made upstream of Picayune Chute near River Mile 56R (Figure 3.3-5). The area contains numerous fallen trees and log snags. Mud, silt, detritus, and sand substrates are common, and typical water depths are 3 to 6 feet. This site most recently received dredged material in 1970.

Station 13--Revetted Littoral

Revetted littoral areas are common throughout the study site. Currents are generally swifter at the revetted areas than at the natural areas. Collections were undertaken along the Missouri bank below Sciem and Flora Creeks (Figure 3.3-5). Rock, sand, and mud substrates are present. Habitat diversity in the form of fallen trees (Salix sp.) occurs during high water periods. Water depths are typically 1 to 3 feet immediately adjacent to the bank, while depths of 5 to 12 feet are typical 10 to 15 feet riverward of the bank.

Station 14--Pile Dike

Pile dikes are uncommon at the Cape Girardeau study site. Collections were made near River Mile 62 on the Missouri side of the river (Figure 3.3-5). Sampling at this site was conducted at one full pile dike in a degraded condition and one old pile dike that had been

partially modified into a stone dike. Substrates at the sites are mud and sand; depths are typically 2 to 5 feet. Current is slack, except near the distal end of the dikes.

Station 15--Stone Dike

Stone dikes are common throughout the study area. Samples were collected near River Mile 57R above Scism and Flora Creeks on the Missouri bank. The stone dike areas are similar to those at the Ste. Genevieve site. The dikes are set perpendicular to the current, with typically swift currents near the distal end and slack currents at the base. Water depths and substrates vary with the currents. Deeper water, 8 to 20 feet, with sand substrate is typical at the distal end of the dikes. Shallow water, 1 to 5 feet, with mud silt substrates is found at the base of the dikes.

Station 16--Mouth of Tributary

The mouth of the Scism and Flora Creeks (River Mile 56R) was selected as the sampling area for this habitat type at Cape Girardeau (Figure 3.3-5). Both creeks are shallow (2 to 6 feet) and narrow (40 feet average width). Flora Creek is more turbid with less habitat diversity than Scism Creek, which has numerous log snags and fallen trees. Bottom composition is mud, and water current velocity is slack. The creeks join just prior to their confluence with the Mississippi.

4.0 METHODS

The methods utilized in this study are those specified in the project Scope of Work or in project initiation meetings with the COE and FWWG. The chairman and members of the FWWG provided valuable technical advice and review throughout the study, as did COE personnel.

4.1 HABITAT MAPPING

ESE prepared habitat maps for the entire GREAT III reach. The base maps provided by the COE were 1:24,000 scale topographic maps which were drawn and compiled into 21 sections or plates (13 open river, 8 pooled river) by the U.S. Geological Survey (1979). The habitat maps were produced on transparent mylar for overlaying on the USGS base maps.

The habitats mapped were those defined in Section 2.0. Habitats were designated on the overlays by various geometric patterns. Borders of streams, lakes, and ponds were drawn in ink as were all dikes (wing dams). The boundaries of the study area were the obvious edges of the floodplains (i.e. bluffs and levees).

Each of the map overlays produced shows the identified aquatic habitats and dikes. The number of river miles covered and a key to the patterns which designate the habitat types are also included on each overlay.

Several sources were used to delineate and verify the aquatic habitats mapped. The USGS base maps were the primary data source utilized for the open river. For the pooled river, both the USGS base maps and the maps of Yarbrough and Hensley (1980) served as important data sources. The most recent navigation charts (U.S. Army 1978, 1979) were also used, particularly for locating the route of the main channel and the dikes.

Two sets of aerial photographs were utilized to verify habitats identified from the base maps and navigation charts. One set of photos was dated 1975 and had a scale of 1:6,000 (Mark Hurd Aerial Surveys, Inc. 1975). The second set of photos were taken for the COE in July of 1980 when the river stage was approximately 5 to 6 feet at the St. Louis gage. These 1:12,000 scale photos were used only on the open river. The photos were viewed with a Bausch and Lomb zoom transfer scope to

compare locations of dikes, islands, and side channels. Using the scope, the overlay images were transferred onto the aerial photographs at the same scale so that accurate comparisons were possible. Comparisons of habitat areas were hindered by differences in water levels between the photos and the overlays.

After the habitats were identified from the photographs and maps, they were delineated on transparent sheets to overlay the USGS base maps. Acreages of each habitat were then measured from the habitat overlay maps.

Areas of each habitat type on the open river were measured using a polar planimeter. To ensure accuracy, three planimeter readings were taken for each unit of habitat, and these were averaged to provide the final figure. Due to unanticipated delays in mapping the aquatic habitats of the pooled river, a more rapid method of measuring habitat acreages was required. The dot grid method was selected for use on the pooled river because it is an accurate but faster alternative to the planimeter method (Avery 1968, Mosby 1971). Each dot on the grid used in this study represented 2.55 acres on the 1:24,000 scale habitat maps.

Habitat acreages were compiled according to the river reaches presented on the 21 GREAT III base maps. In addition, total habitat acreages were reported for the open and pooled river segments of the GREAT III study area. Because acreage is dependent in part upon water level, acreage calculations from ESE maps will not be exactly comparable to acreages measured at other water levels or water years.

Because some of the base maps compiled by the USGS used information more than 10 years old, the FWWG hoped to identify changes that had occurred in the river habitats since the earliest maps were drawn. However, a detailed analysis of the habitat changes would require production of sets of maps or photographs from the two time periods at comparable water levels. Unfortunately, neither of these sources was available and, therefore, only gross habitat changes were identified.

4.2 FIELD SAMPLING

The methodologies and equipment utilized in the field sampling portion of the GREAT III Ecological Characterization were generally those specified by the Fish and Wildlife Work Group (FWWG) in the contract work scope. Exact methodologies and equipment specifications were finalized in a project initiation meeting with the COE and FWWG. The methods and equipment selected were those that the FWWG feels are most effective in sampling the various aquatic habitats found in the GREAT III reach. Methods were similar to those used in GREAT II studies and in previous studies in the GREAT III reach. This allows all data bases to be compared. Also, data from other studies can be used to support data collected in this study.

The various sampling methods used in each habitat type are indicated in Table 4.2-1. Table 4.2-2 designates the number of samples to be collected as per the Scope of Work. Subsequent text describes the level of sampling effort for each sampling method. Section 8.0 of the text discusses gear bias and sampling problems associated with the various sampling methods utilized. Table 4.2-3 provides dates of each sampling period and site.

The emphasis in the field sampling program for this study was on the various fish communities and determining the habitat associations and utilization of habitat by species and groups. Seven methods were used to sample the fisheries, depending upon habitat type:

Electrofishing,
Hoop net,
Gill net,
Trammel net,
Frame (trap) net,
Ichthyoplankton net,
Seine,

Table 4.2-1. Quantitative Biological Sampling Methods Utilized at Each Sampling Habitat During the GREAT III Biological Sampling Program

		Sampling Method*									
	Habitat† Location	Electro-shocking	Frame Netting	Gill Netting	Hoop Netting	Trammel Netting	Trawling	Seining	Ichthyo-Plankton	Ponar Grabs	Mussel Brailling
Tailwaters	P	X		o		o	X		X		
Navigation Pool	P	X	X	X					X	X	
River Lakes and Ponds	P	X	X	X						X	
Sloughs	P	X	X	X						X	
Downstream end of Island	P	X	X	X						X	
Dike Field	P	X		o	X	o				X	X
Main Channel	O,P						X		X		X
Main Channel Border											
- Inside	O,P	X		o	X	o				X	X
- Outside	O,P	X		o	X	o				X	X
- Straight	O,P	X		o	X	o				X	X
Side Channel	O,P	X		o		o				X	X
Natural Littoral	O,P	X						X	X	X	
Revetted Littoral	O,P	X							X	X	
Pile Dike	O	X		X						X	X
Stone Dike	O	X		o	X	o				X	X
Mouth of Tributary	O	X			X						

† P = Pooled River
O = Open River

* X = Sampling conducted during all four sampling periods.
o - Trammel netting sampling periods 1, 2 and 3 replaced by gill netting sampling period 4.

Source: ESE, 1982.

Table 4.2-2. Samples Designated to be Collected at Each Study Site

Station*	Electrofishing				Frame Netting				Hoop Netting				Trammel Netting				Gill Netting				Seining				Trawling			
	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi
1	2	2	2	2									2	2	2	0	0	0	0	1					3	3	3	3
2	2	2	2	2	3	3	3	3									1	1	1	1								
3	2	2	2	2	3	3	3	3									1	1	1	1								
4	2	2	2	2	3	3	3	3									1	1	1	1								
5	2	2	2	2	3	3	3	3									1	1	1	1								
6	2	2	2	2					12	12	12	12	2	2	2	0	0	0	0	1								
7																									6	6	6	6
8	2	2	2	2					12	12	12	12	2	2	2	0	0	0	0	1								
9	2	2	2	2					12	12	12	12	2	2	2	0	0	0	0	1								
10	2	2	2	2					12	12	12	12	2	2	2	0	0	0	0	1								
11	2	2	2	2									2	2	2	0	0	0	0	1								
12	2	2	2	2																	2	2	2	2				
13	2	2	2	2																								
14	2	2	2	2									2	2	2	0	0	0	0	1								
15	2	2	2	2					12	12	12	12	2	2	2	0	0	0	0	1								
16	2	2	2	2					12	12	12	12																

Sampling level of effort: Electroshocking (30 minutes), Frame netting (net day), Hoop netting (net day), Trammel netting (10 minutes), Gill netting (net day), Seining (1 hour), Trawling (10 minutes).

* Stations 1-6 were sampled exclusively at the pooled river sites. Stations 14-16 were sampled exclusively at the open river sites. Stations 7-13 were sampled at all sites.

Source: ESE, 1982.

Table 4.2-3. Dates of Sampling Efforts in Each Season and at Each Study Area

	Spring (I)	Summer (II)	Fall (III)	Winter (IV)
Clarksville	April 27 - May 1*	June 29 - July 3	August 16-20	October 5-9
Winfield	May 4 - May 8†	June 22-26	August 23-29	October 12-16
Ste. Genevieve	May 11-15	July 7-10	September 21-25	November 2-6**
Cape Girardeau	June 15-19	July 20-23	August 31 - September 3	November 16-25††

* Completion June 2-5.
† Completion June 9-12.
** Preliminary collections (Benthos, Ichthyoplankton, Mussels) October 26-30.
†† Preliminary collections (Benthos, Ichthyoplankton, Mussels) November 2-6.

Source: ESE, 1982.

Otter trawl, and
Chemofishing.

FISHERIES

Electrofishing

A boat-mounted boom type electrofishing unit was used throughout the study. Pulsed D.C. outputs ranging from 180 to 220 volts and 7 to 12 amps were used. In each habitat, two 30-minute runs were made during each sampling period. Two persons performed the electrofishing, one as a bow netter and the other operating the boat and monitoring equipment performance. Most stunned fish were netted and placed in holding tanks for later processing. Some stunned fish were missed, and extensive numbers of gizzard shad necessitated subsampling of representative size ranges.

To the extent possible, electrofishing efforts focused on shallow waters and areas of cover (snags, brush). If currents were present, electrofishing was generally accomplished by moving with the current to provide more control over boat movements.

Otter Trawl

Trawling was only conducted in the main channel and tailwater. The trawl is the only method that can be used in deep, fast-moving waters. The trawl used was a 20-foot, 1-inch bar mesh, semi-balloon otter trawl, with a 1/4-inch cod end liner.

In the main channel, three 10-minute trawls were made at mid-depth and three on the bottom. In the tailwaters, only three mid-water trawls were made. All trawls were performed against the current at sufficient speed to maintain progress through the water but to prevent capsizing. In instances where currents were too strong, or river conditions hazardous, trawling was not performed or was postponed due to personnel safety considerations. Initially, trawling both upstream and downstream

was conducted, without significant differences in results. The upstream tow was decided upon for safety reasons.

Seine

Seining was conducted only in natural littoral zones during all sampling periods when flow conditions allowed access to shallow littoral areas suitable for seining. Two hours of seining were conducted during each sampling period at each site. Two types of seines were used for approximately 1 hour each, a 50- by 6-foot, 1/4-inch mesh seine and a 25- by 4-foot, 1/8-inch mesh seine. Seining was conducted in waters generally less than 5 feet in depth.

Hoop net

Hoop net collections were made during each sampling period in those habitats indicated in Table 4.2-1. Hoop nets used were 2 1/2 feet in diameter with 7 hoops and 1-inch square mesh. In each habitat sampled, 4 hoop nets were placed for a 72-hour collection period. Nets were checked and emptied daily. Water level fluctuations sometimes necessitated minor relocations of nets on a daily basis. Nets were set with the mouth opening downstream. Nets were not baited.

Gill Net

During each sampling period, 24-hour bottom and/or surface gill net sets were used in the habitats indicated in Table 4.2-1. Nets were 300 feet in length and 6-foot deep. Five panels, 60 feet in length, were of the following square mesh and sequence: 3/4-inch, 1-inch, 1 1/4-inch, 1 1/2-inch and 2-inch.

Surface sets were floated on the surface, and bottom sets were anchored just off the bottom. All sets were placed perpendicular to the shoreline, with smaller meshes near shore. With gill net collections, note was made regarding mesh size in which fish were collected.

During the last quarter of sampling, gill nets replaced the trammel net collections due to the limited success of trammel net methods. Depending upon depth, either a bottom or surface set was made for a 24-hour period in those habitats previously sampled with the trammel net.

Trammel Net

Trammel nets were used during the first three sampling periods in those habitats indicated in Table 4.2-1. Nets were initially 300 feet in length and 6 feet in depth. After the first sampling period, length was reduced to 150 feet for easier deployment. Mesh was 2-inch square throughout. Nets were not set, but were surface-floated perpendicular to the current. During each sampling period, two 10-minute floats were made in each habitat sampled. Because of low yield with this method, trammel nets were replaced by stationary gill net sets during the fourth sampling period.

A majority of fish collected by the above methods were handled in the field. All individuals were identified and measured (total length); smaller individuals were preserved for laboratory processing. Notes of maturity, parasitism or other unusual features were also made as appropriate.

Frame (Trap) Net

Frame nets were utilized in each habitat as indicated in Table 4.2-1, in all sampling periods. The nets were of the following dimensions:

Two 3x6 foot leading frames,
Four 2-foot diameter hoops,
One 50x3.5 foot lead,
Two 15x3.5 foot wings, and
3/4-inch bar mesh.

Nets were set in water sufficiently shallow to allow some portion of the net to be out of the water (minimizing mortality of turtles caught) and

to allow lead to extend to shore. Nets were set with lead perpendicular to net and shore, with the wings set at approximately 45° angles to the net body. Three nets were set concurrently for 24 hours in each habitat sampled, during each sampling period. Nets were emptied early each morning to minimize mortality of fish and turtles caught.

Ichthyoplankton

Ichthyoplankton collections were made during each sampling period in those habitats indicated in Table 4.2-1. Collections were made with a tandem conical net sampler. The nets were of 500-micron mesh nitex netting, having a 0.5 m diameter mouth. Nets were metered with a general oceanics mechanical flow meter. Two nets were mounted in a tandem frame for simultaneous towing and replication. During each sampling period, a single 10-minute tow of the tandem nets was made in each of the habitats sampled. Tows were made in daylight hours, at or near the water surface. After sampling, nets were washed, the contents concentrated by washing, and the organic contents preserved in 10 percent neutral buffered formalin.

Chemofishing

The chemofishing survey was undertaken of September 24, 25, and 26, 1981. During this period and for several days prior to and after the survey, the Kaskaskia side channel was cut off from the Mississippi River. Based on data received from the St. Louis COE it was determined that the Kaskaskia side channel is cut off when the St. Louis stage reaches approximately 8 feet. Sampling was undertaken at a St. Louis stage of 5 feet. Based upon data received from the St. Louis COE, the Kaskaskia side channel at this stage contained approximately 11.5 surface acres, 45-acre-feet, and 1.5 miles of shoreline. Shoreline measurements and depth profiles undertaken prior to chemofishing confirmed these dimentsions.

Data received from the St. Louis COE and confirmed in the field indicated that 57 percent of the water was 0 to 4 feet in depth,

35 percent 4 to 10 feet in depth, and 8 percent greater than 10 feet deep.

Chemofishing was undertaken using a 5 percent emulsified rotenone solution as described in Bennett (1971). The rotenone was surface-applied along the side channel circumference, as well as by making concentric circles around the side channel from the shoreline to the center. Rotenone was also released into the deeper water zones. This was accomplished by pouring rotenone through a weighted hose into the deeper waters, at varying depths, while making a zigzag pattern in the deep water areas.

Sixty gallons of 5 percent rotenone solution were released into the side channel producing an approximate concentration of 4.0 ppm. This concentration is higher than 1 to 3 ppm suggested for complete kills (Bennett 1971). To verify the effectiveness of chemofishing, 2 hoop nets (each with 3 carp and 3 channel catfish) were set in the deeper water areas of the side channel. At the end of the first day, the nets were checked. One net was found; all fish in the net were dead. The remaining net was not found.

The rotenone was applied between 10 a.m. and 12 p.m. on September 24, 1981. Immediately after application, the crews began dip netting the dying fish as they came to the surface. The fish were taken from the water, and brought to a central location on the bank for processing. Processing consisted of identification, enumeration, weighing, measuring, and disposing (burying) of all fish collected. By the end of the first day, few newly killed fish appeared to be surfacing. The second and third days were spend processing the remaining fish. Subsampling procedures, including bulk weighing and visual counts of the remaining fish, were employed to aid in the complete inventory of all fish within the side channel.

Based upon the large number of fish collected and the death of the fish in the hoop net, it is believed that most, if not all, of the fish in the side channel were killed and inventoried. However, it is not known how many fish died and sank to the bottom before they could be recovered.

BENTHOS

Benthic macroinvertebrate collections were made with a petite ponar dredge in the habitats indicated in Table 4.2-1. During each sampling period three dredge grabs were taken in each habitat. The three grabs were washed in the field with a No. 30 mesh sieve bucket, composited into a single sample and preserved in 10 percent buffered neutral formalin. No sampling of hard substrates (e.g. revetments, dikes) occurred.

Mussels were collected using a 10-foot crowfoot brail, constructed according to specifications provided by the FWWG. During each sampling period, two 10-minute tows were made in each habitat sampled. Tow speed was held to a level necessary to maintain progress while keeping the brail hooks on the bottom. All tows were made downstream.

Fingernail clam data were collected at 4 locations in the pooled river during late March and early April, 1982. Collection sites were determined by the FWWG and ESE based upon fall and winter 1981/82 aerial surveys of diving duck concentrations (Illinois Natural History Survey) and the historic locations of diving duck concentrations. At each selected site, triplicate composited petite ponar grabs were made at six discrete locations. Bottom strata were visually estimated at each sampling location. River flow (estimated), temperature, dissolved oxygen, pH, and ammonia concentration data were measured at one location at each site. Laboratory processing entailed the handpicking of all mollusc and mollusc shells from the samples. All sphaerids in the collections were identified to the lowest practical taxon (genus).

QUALITATIVE METHODS

Qualitative observations were made throughout the study to determine utilization of the study reach by mammals, birds, reptiles, and amphibians. During all sampling efforts, a record was kept of birds, mammals, and herpetofauna observed. In addition, mud flats and river banks were routinely searched for tracks and other signs. The emphasis in this part of the study was to determine the dominant faunal communities and species present in various aquatic and semi-aquatic habitats.

In addition to faunal observations, notes were kept on occurrence of aquatic macrophytes and other unique or natural features throughout the study period.

4.3 LABORATORY

Upon return from the field, all samples were logged-in, numbered, and properly stored for future processing. Sorting of benthos and ichthyoplankton was done in white pans under lighted magnifiers. Fish samples were identified and measured. In some cases, the volume of samples necessitated subsampling of benthos. Total volumes were split and the processed volume recorded.

Identification was performed by standard compound and dissecting microscopy. The following taxonomic keys were consulted in making identifications:

Brinkhurst, 1975	Ross, 1944
Burks, 1953	Smith, 1979
Edmonson, 1959	Wiggins, 1977
Fish, 1932	Merritt and Cummins, 1978
Hilsenhoff, 1975	Holsinger, 1972
Hogue, et al., 1976	Schuster and Etnier, 1978
Lippson and Moran, 1974	Mackie et al., 1980
Mansueti and Hardy, 1967	Edmunds et al., 1976
Mason, 1973	Beck, 1975
May and Gasaway, 1967	Johannsen, 1937
Pennak, 1978	Curry, 1961
Pfleiger, 1975	Saether, 1977

Identifications, using current nomenclature, of aquatic organisms were made to the following taxonomic levels:

- Adult fish - species
- Larval fish - species, as practical
- Worms - class
- Diptera - family or genus
- Ephemeroptera, Plecoptera, Trichoptera - species, as practical

Odonata - family

Mussels - species

Snails, Crustaceans, Other Benthic Organisms - order.

ESE has maintained a voucher collection of all benthos (including mussel) taxa collected and specimens of all smaller fish species collected.

4.4 DATA CALCULATIONS AND ANALYSIS

No significant statistical analyses were conducted with the data collected in this study, due to the numerous variables of sampling methods, river conditions and time spread during individual sampling periods. However, a number of calculations were made to allow characterization of habitats and biota and to compare habitats, seasons, and sampling methods and areas.

For the benthic invertebrate data, estimates of percent occurrence and density (No./m^2) were calculated as were diversity and evenness indices. For fisheries data, percent occurrence and CPE (catch per unit effort) were calculated as were diversity and evenness indices. Length-frequency analyses were conducted on the major species for each habitat type.

The Shannon-Weaver index (Odum, 1971) was used to calculate species diversity:

$$\bar{d} = (\Sigma \frac{ni}{N}) \text{ Log}_2 (\Sigma \frac{ni}{N})$$

where: n = # individuals in i^{th} taxa
N = # individuals in sample.

Where all organisms were not identified to the same taxonomic level, as with many of the benthos samples, diversity was calculated assuming one species per genus or family in which no species was assigned by identification. Thus the calculated diversity values were probably slightly conservative.

The evenness index (Odum, 1971) was calculated using the following formula:

$$e = \bar{d}/\log_e \text{(No. Species or Taxa)}.$$

Taken together, the diversity and evenness provide useful comparative tools for evaluating biotic communities, assuming similar sampling methods and effort are used. Higher diversity and evenness values generally suggest more stable, healthy biotic communities experiencing few environmental or ecological stresses. The reverse is indicated by low diversity and evenness values.

For the benthos, two types of diversity and evenness values were calculated. Because of the heavy domination of Oligochaeta in the samples collected, values were calculated including and not including the Oligochaeta, in an attempt to characterize the non-oligochaete benthos and emphasize the importance of non-oligochaetes in the benthos.

Utilizing diversity and evenness indices to describe or compare biotic communities must be done or interpreted carefully. Information on the pollution or ecological sensitivity, life history requirements, taxonomic composition, and productivity must also be considered in combination with index values.

4.5 SAMPLING PERIODS AND ASSOCIATED RIVER CONDITIONS

River conditions in the GREAT III reach during 1981 were atypical and highly variable. Figures 4.5-1 through 4.5-6 compare river stages and flows during 1981 and the study period, with statistical averages from historical data.

The first quarter of 1981 was characterized by near-record low water levels throughout the Upper Mississippi River, as was true during most of 1980. The second, and a majority of the third, quarter of 1981 saw a return to high water levels with flood stage or near-flood stage conditions occurring on several occasions. Water levels remained atypically high throughout the summer and did not return to lower, more typical levels until late September. Fall and early winter river conditions were generally typical, with river levels stabilizing at relatively low levels. Reduced precipitation decreased the inputs of surface runoff into the Mississippi basin.

As a result of these unusual river conditions, the spring, summer, and first half of the fall sampling period were affected by abnormally high and unstable river conditions. River conditions during the last half of the fall sampling period and the winter sampling period were more typical. Section 8.0 discusses the effects of the river conditions on the field data collection efforts.

Also, as a result of the high water conditions during the year, a majority of side channels remained flowing throughout the study. The notable exception was the Kaskaskia side channel, which was cut off in early fall. The other side channels sampled flowed throughout the study period.

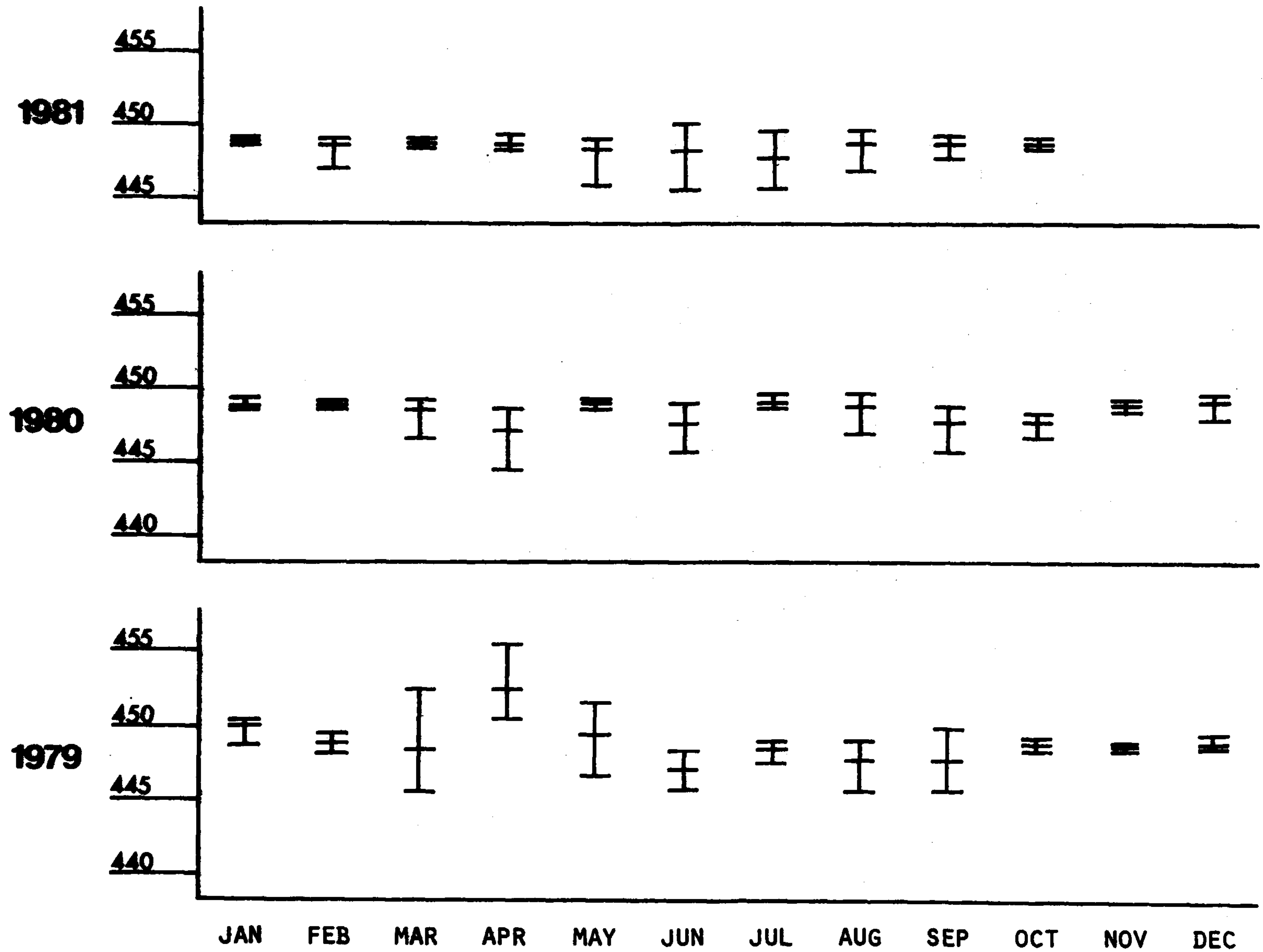


FIGURE 4.5-1 VARIATION IN MISSISSIPPI RIVER STAGE AT CLARKSVILLE POOL
RM 273.5

GAGE ZERO = -0.19 FT MSL

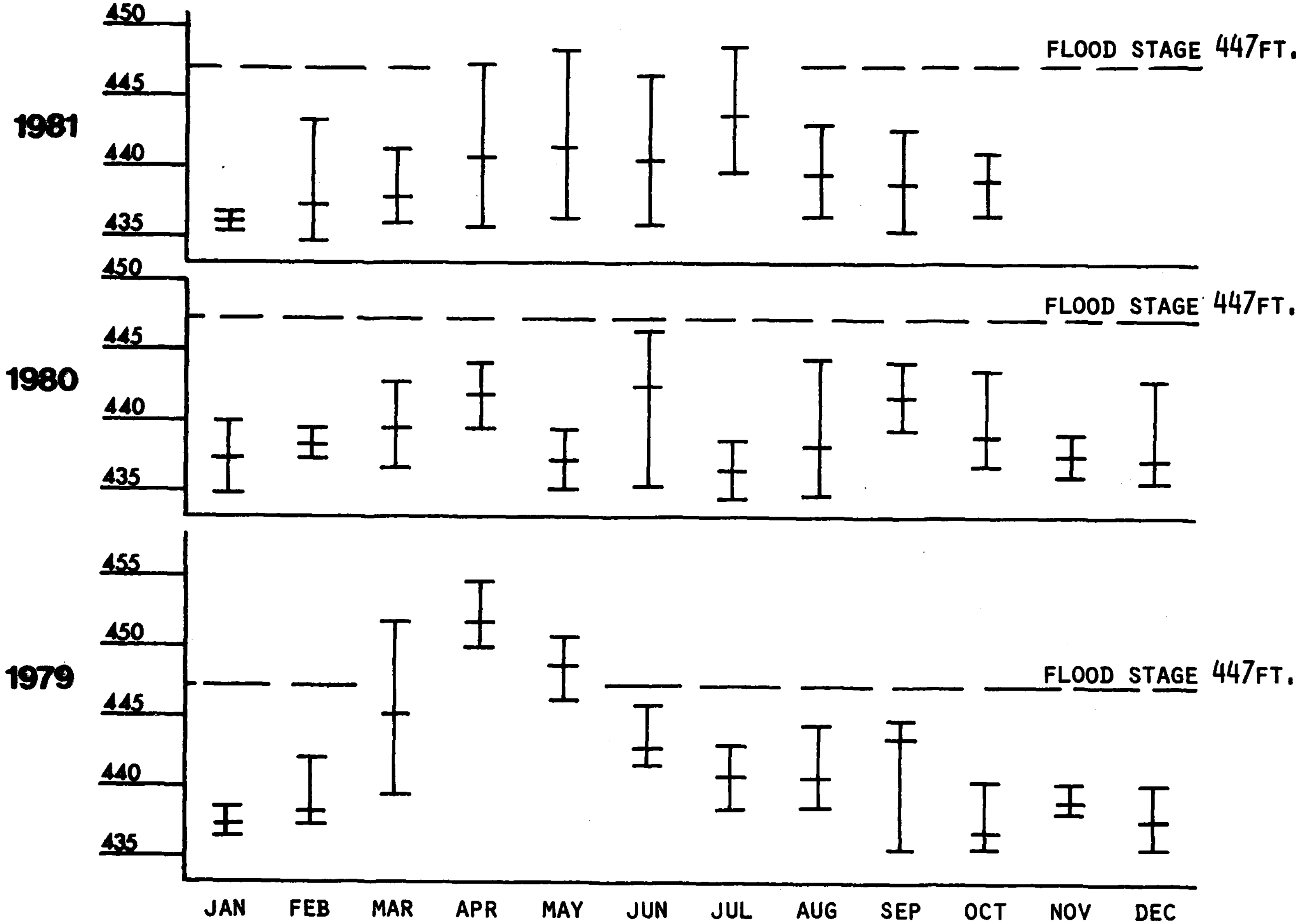


FIGURE 4.5-2 VARIATION IN MISSISSIPPI RIVER STAGE AT CLARKSVILLE L & D TAILWATERS RM 273.2

GAGE ZERO = -0.19 FT MSL

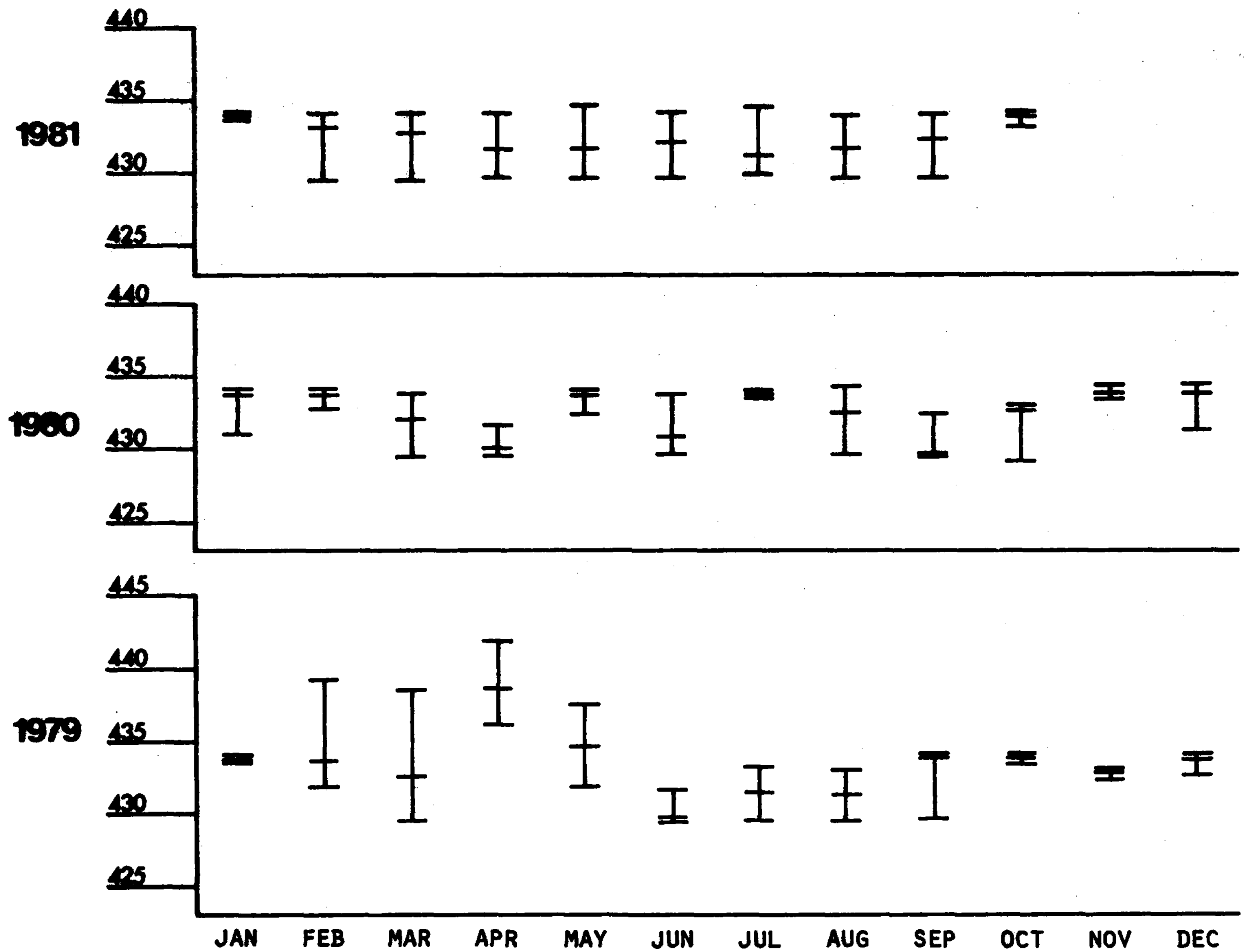


FIGURE 4.5-3 VARIATION IN MISSISSIPPI RIVER STAGE AT WINFIELD, MO. (L&D 25 UPPER) RM 241.5

FOOTNOTE - GAGE ZERO = +0.09 FT MSL

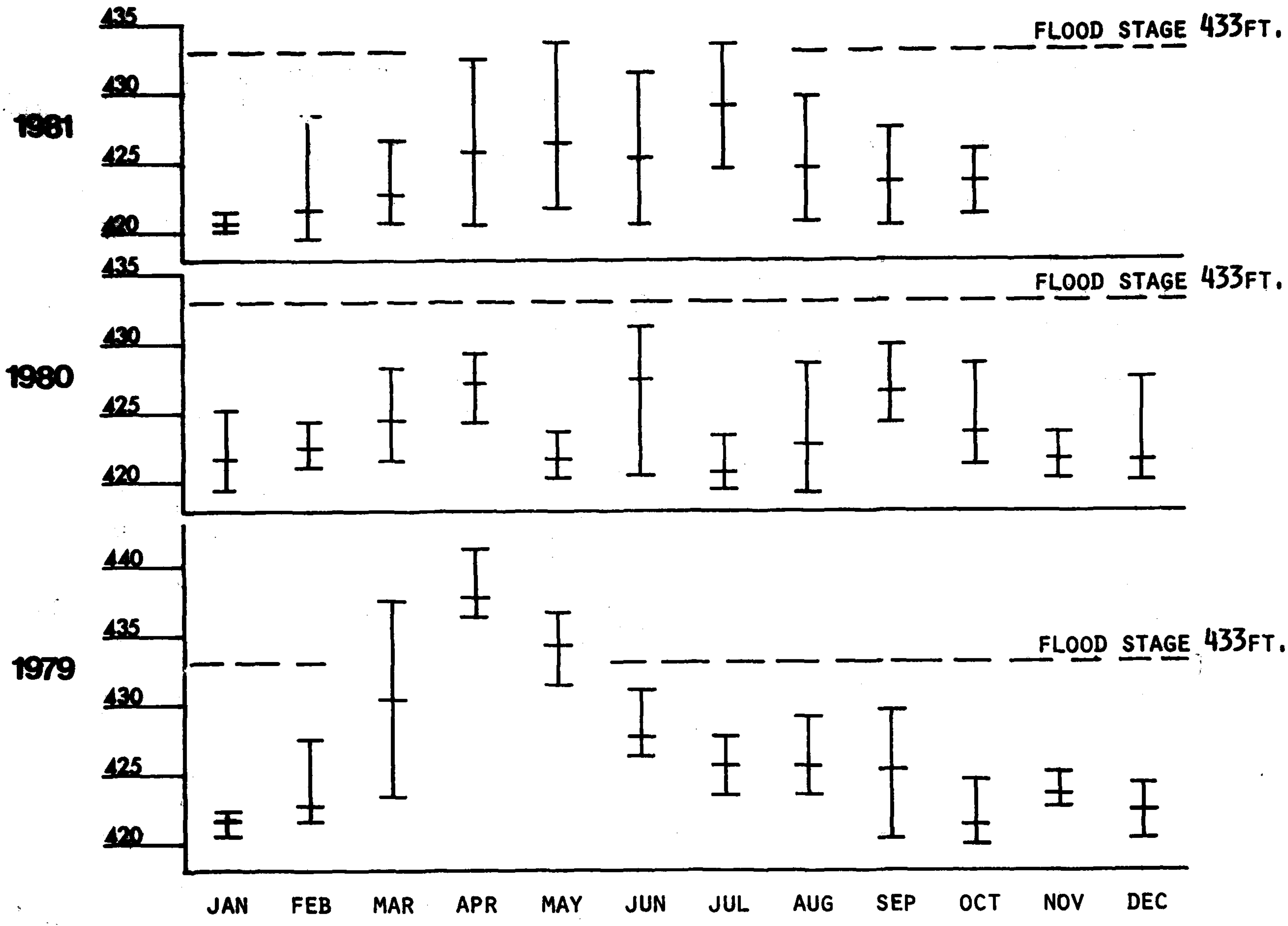


FIGURE 4.5-4 VARIATION IN MISSISSIPPI RIVER STAGE WINFIELD, MO. (L&D 25) TAILWATERS RM 241.2

GAGE ZERO = +0.09 FT MSL

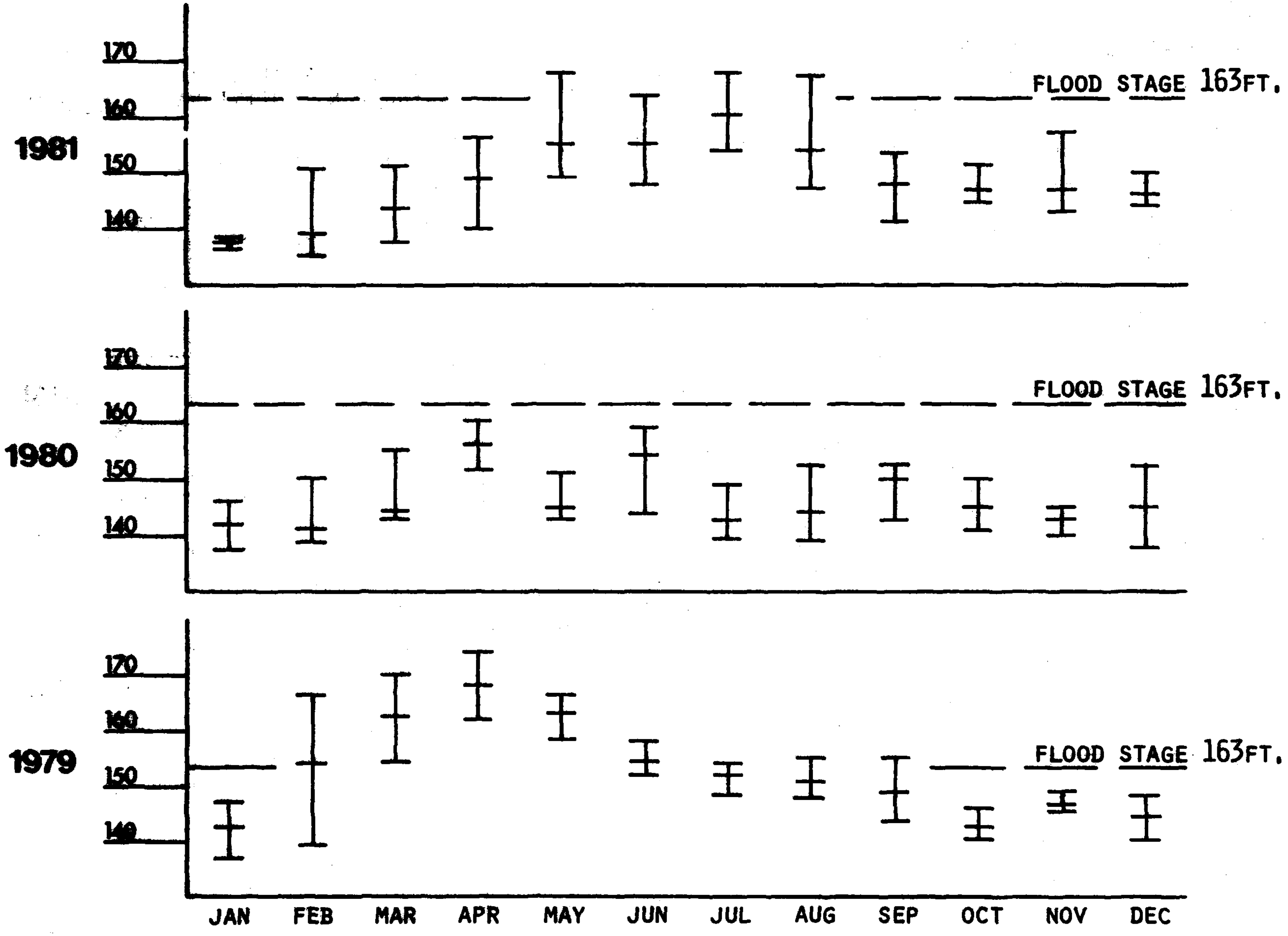


FIGURE 4.5-5 VARIATION IN MISSISSIPPI RIVER STAGE - HIGH, MEAN, LOW
LITTLE ROCK LANDING, MO. RM 125.5

FOOTNOTE - GAGE ZERO = 213.79

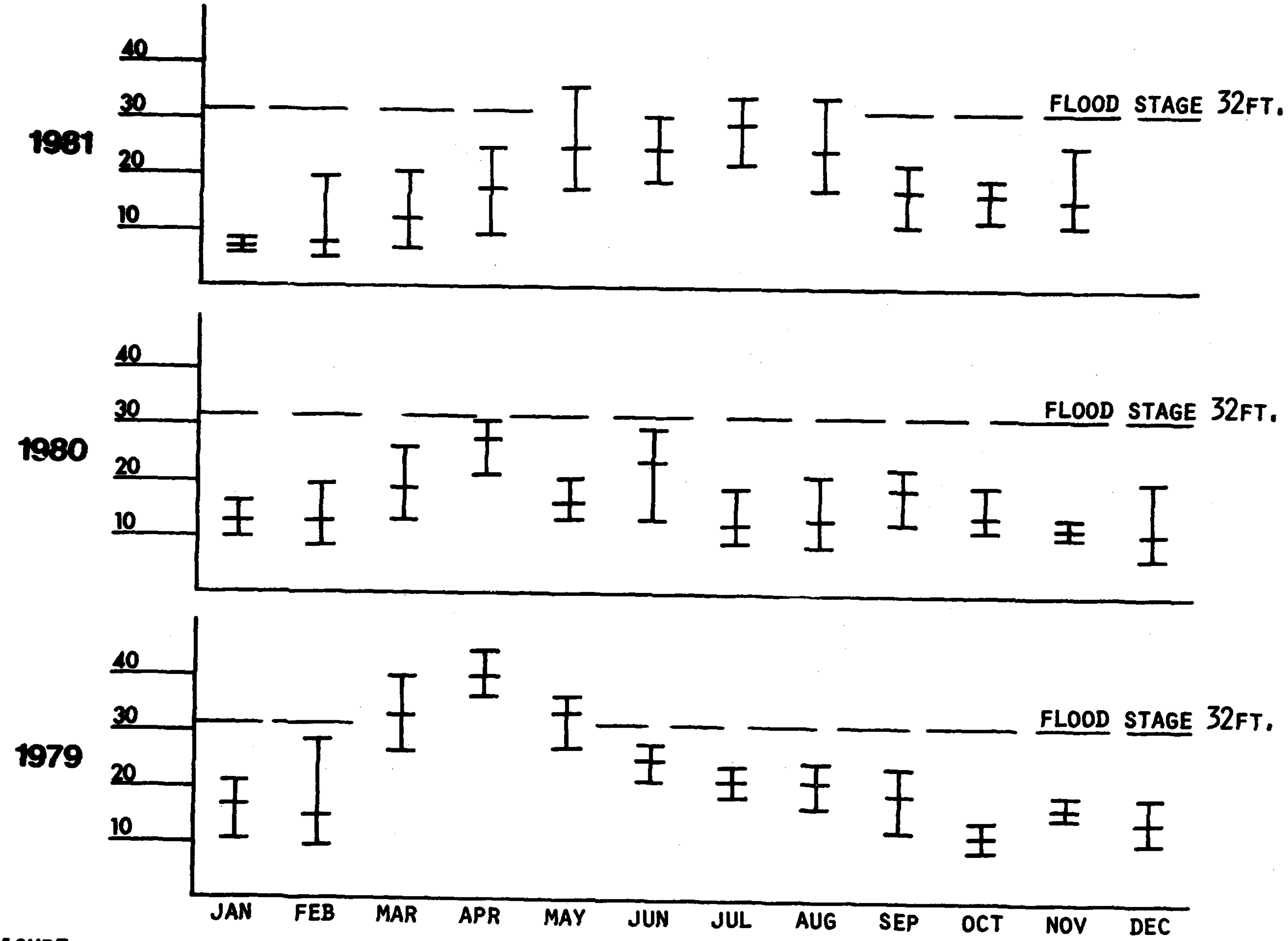


FIGURE 4.5-6 VARIATION IN MISSISSIPPI RIVER STAGES - HIGH, MEAN, LOW FOR 1979, 1980, AND 1981 AT CAPE GIRARDEAU, MO. RM 52.1

GAGE ZERO = 304.65 FT MSL

5.0 HABITAT CHARACTERIZATION

5.1 HABITAT MAPS AND ACREAGES

Maps of aquatic habitats of both open and pooled river segments of the GREAT III reach are presented in Figures 5-1 to 5-53. Each of these figures represents a 4-10 mile segment of one of the 21 GREAT III base maps.

Both habitat maps and geophysical base maps are provided in Figures 5-1 to 5-53. A key to the habitat symbols is provided in a frontispiece to the maps. All maps shown in this report are 1:48,000 scale; full size (1:24,000 scale) original mylar habitat maps were provided to the St. Louis COE.

Tables 5.1-1 and 5.1-2 provide the acreages of each habitat type and the total aquatic habitat acreage in the GREAT III reach. Acreages of each habitat type are compiled according to the reaches shown on the GREAT III base maps.

Table 5.1-1. Acreages and Percentages of Aquatic Habitats in the Open River

River Miles	Main Channel	Main Channel Border: Total	Main Channel Border: Straight Reach	Main Channel Border: Inside Bend	Main Channel Border: Outside Bend	Side Channel	Tributary Mouth	Total	Revetted Littoral Zone (miles)†
1-25	2,421 (37)*	3,640 (56)	3,112 (48)	380 (6)	148 (2)	463 (7)	9 (<1)	6,533	22 (44)
25-43	1,838 (38)	2,216 (46)	1,933 (40)	199 (4)	84 (2)	749 (16)	10 (<1)	4,813	14 (39)
43-63	2,332 (44)	2,267 (41)	1,772 (32)	194 (4)	301 (5)	902 (16)	20 (<1)	5,521	11 (27)
63-79	1,863 (45)	1,955 (47)	1,901 (46)	27 (<1)	27 (<1)	289 (7)	14 (<1)	4,121	3 (9)
79-90	1,144 (41)	1,621 (59)	1,318 (48)	155 (6)	148 (5)	0 (0)	4 (<1)	2,769	2 (9)
90-107	2,015 (44)	2,331 (51)	1,724 (38)	352 (8)	255 (6)	223 (5)	6 (<1)	4,575	13 (38)
107-123	1,833 (43)	1,918 (45)	1,493 (35)	204 (5)	221 (5)	517 (12)	28 (<1)	4,296	14 (44)
123-135	1,248 (40)	1,654 (53)	1,259 (40)	164 (5)	231 (7)	221 (7)	4 (<1)	3,127	9 (38)
135-151	1,916 (51)	1,397 (38)	1,215 (33)	98 (3)	84 (2)	398 (11)	14 (<1)	3,725	7 (22)
151-169	2,305 (48)	2,318 (48)	2,144 (44)	87 (2)	87 (2)	200 (4)	18 (<1)	4,841	7 (19)
169-179	669 (29)	1,608 (69)	1,290 (55)	172 (7)	146 (6)	47 (2)	4 (<1)	2,328	4 (20)
179-189	622 (23)	1,483 (56)	1,061 (40)	229 (9)	193 (7)	551 (21)	3 (<1)	2,659	11 (55)
189-202	831 (24)	2,073 (61)	1,654 (49)	152 (4)	267 (8)	494 (14)	11 (<1)	3,409	12 (46)
Total	21,037 (40)	26,481 (50)	21,876 (42)	2,413 (5)	2,192 (4)	5,054 (10)	145 (<1)	52,717 (100)	129 (32)

* First number is the aquatic habitat acreage between the river miles indicated; number in parentheses is the percentage of total acres.

† First number is the mileage of revetted shoreline (both shores) as measured from navigation charts (U.S. Army Corps of Engineers, 1978); number in parentheses is the percentage of total main channel shoreline that is revetted. Total shoreline mileage is twice the miles listed for each river reach.

Source; ESE, 1982.

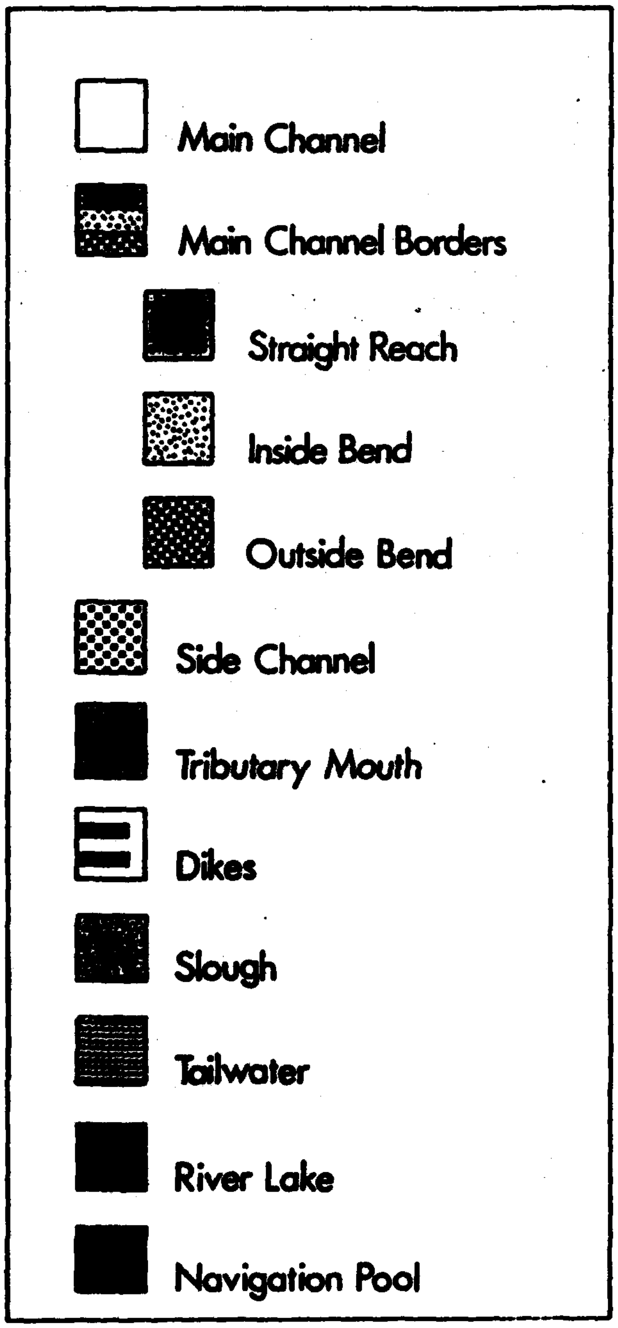
Table 5.1-2. Acreages and Percentages of Aquatic Habitats in the Pooled River

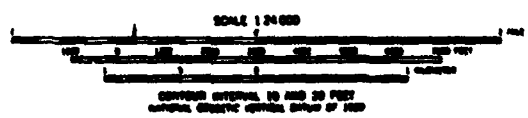
Habitat Types	Acreages and Percentages*								
	River Miles 203-218	River Miles 218-232	River Miles 232-241	River Miles 241-250	River Miles 250-259	River Miles 259-273	River Miles 273-287	River Miles 287-301	Total
Main Channel	1,840 (21)	1,168 (18)	689 (19)	1,071 (16)	801 (16)	808 (16)	905 (15)	966 (20)	8,248 (18)
Main Channel									
Border	3,237 (36)	2,357 (36)	1,437 (41)	2,351 (36)	1,909 (37)	2,030 (39)	2,531 (43)	1,966 (40)	17,818 (38)
Inside Bend	0	145 (2)	0	240 (4)	0	273 (5)	194 (3)	322 (7)	1,174 (3)
Outside Bend	0	217 (3)	0	173 (3)	0	285 (5)	370 (6)	374 (8)	1,419 (3)
Straight Reach	3,237 (36)	1,995 (31)	1,437 (41)	1,938 (29)	1,909 (37)	1,472 (28)	1,967 (34)	1,207 (26)	15,225 (33)
Side Channel	1,104 (12)	2,012 (31)	739 (21)	1,718 (36)	1,545 (30)	1,640 (32)	324 (6)	1,575 (32)	10,657 (23)
Slough	1,102 (12)	598 (9)	156 (4)	429 (7)	380 (7)	153 (3)	173 (3)	159 (3)	3,150 (7)
River Lake	502 (6)	400 (6)	367 (10)	666 (10)	507 (10)	434 (8)	117 (2)	127 (3)	3,120 (7)
Tributary Mouth	3 (<1)	0	6 (4)	0	0	1 (<1)	9 (<1)	1 (<1)	20 (<1)
Tailwater	166 (2)	0	140 (10)	0	0	130 (3)	0	114 (2)	550 (1)
Navigation Pool	1,018 (11)	0	0	336 (5)	0	0	1,788 (31)	0	3,142 (7)
Total	8,972 (100)	6,535 (100)	3,534 (100)	6,571 (100)	5,142 (100)	5,196 (100)	5,847 (100)	4,908 (100)	46,705 (100)
Revetted Littoral Zone (miles)†	7 (23)	9 (32)	3 (17)	6 (33)	6 (33)	10 (36)	8 (29)	8 (29)	57 (29)

* First number is the aquatic habitat acreage between the river miles indicated; number in parentheses is the percentage of total acres.

† First number is the mileage of revetted shoreline (both shores) as measured from navigation charts (U.S. Army Corps of Engineers, 1978); number in parentheses is the percentage of total main channel shoreline that is revetted. Total shoreline mileage is twice the miles listed for each river reach.

Source: ESE, 1982.





LEGEND FOR HABITAT MAPS

SCALE FOR GEOPHYSICAL/HABITAT MAPS

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

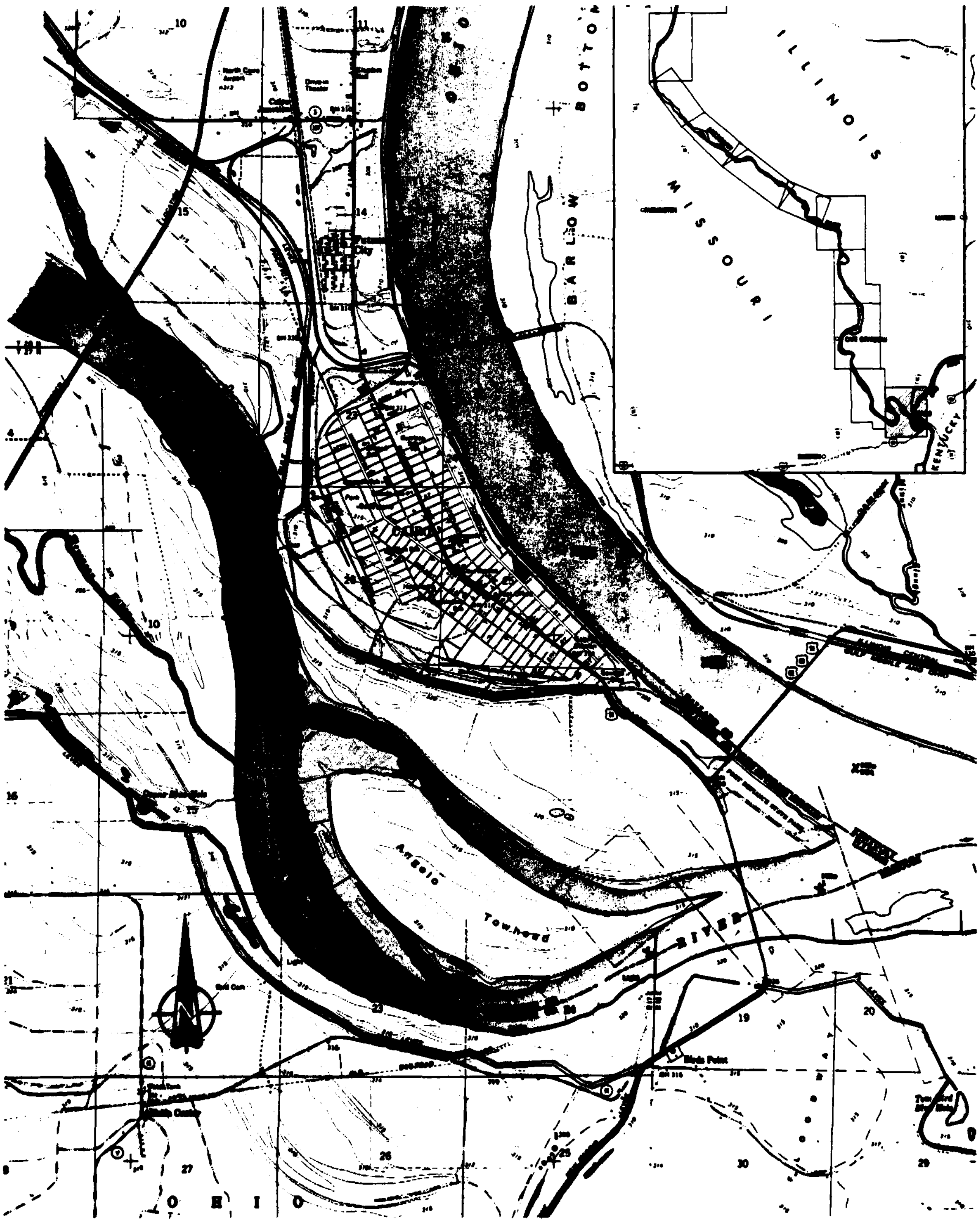


Figure 5-1
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 0-8
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

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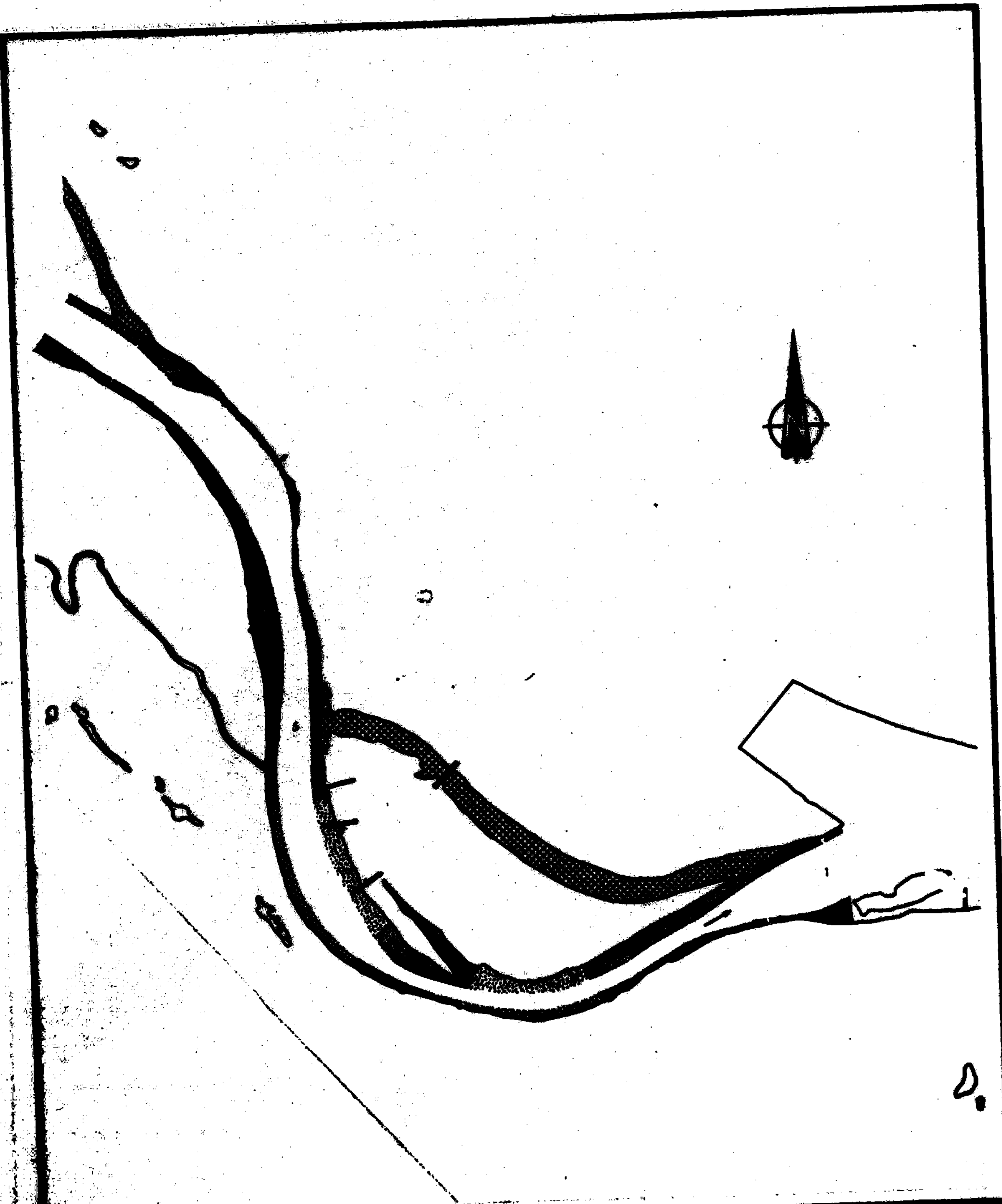

GREAT III ECOLOGICAL CHARACTERIZATION

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Figure 5-2
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 8-20
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

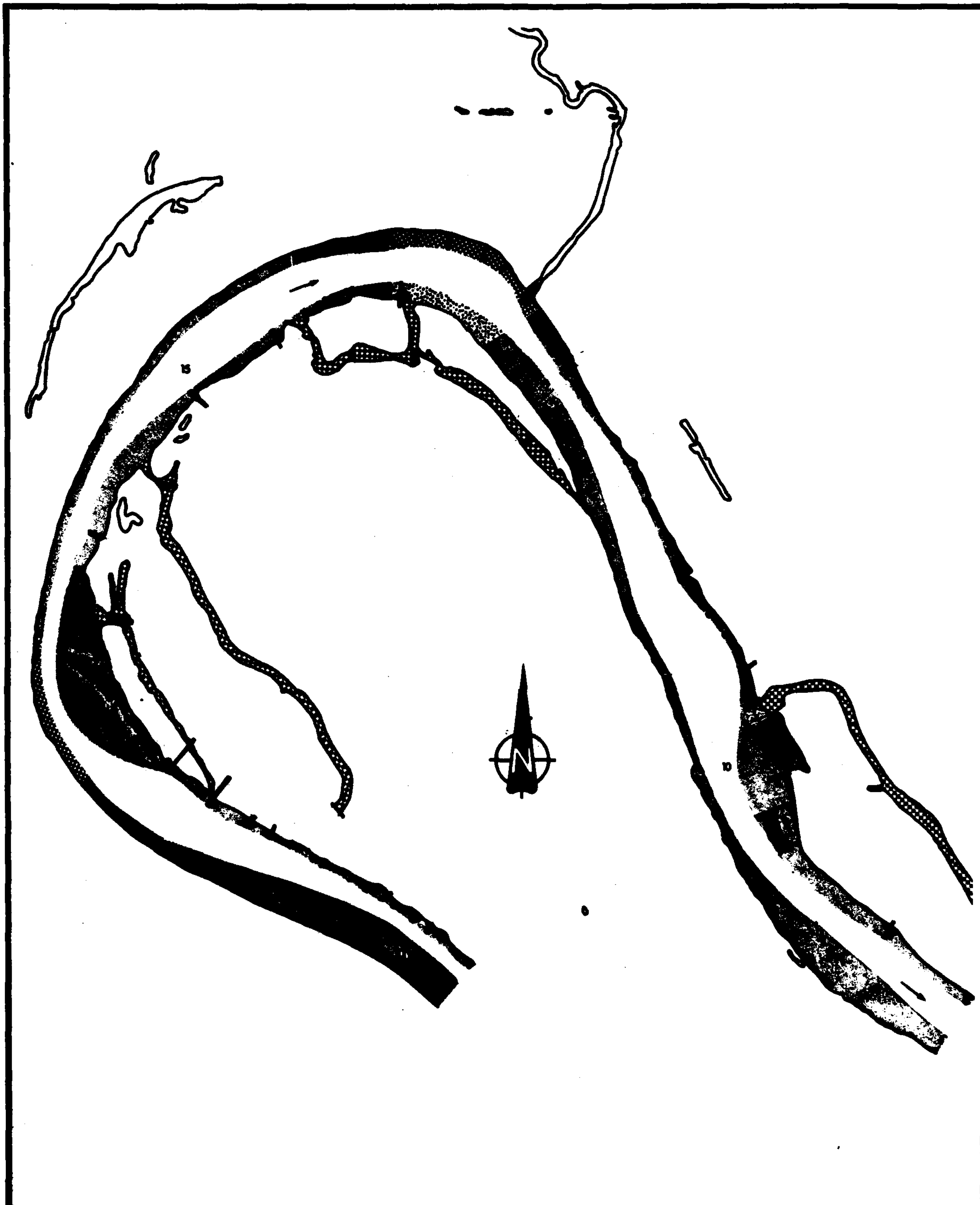

Figure 5-2
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 8-20
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

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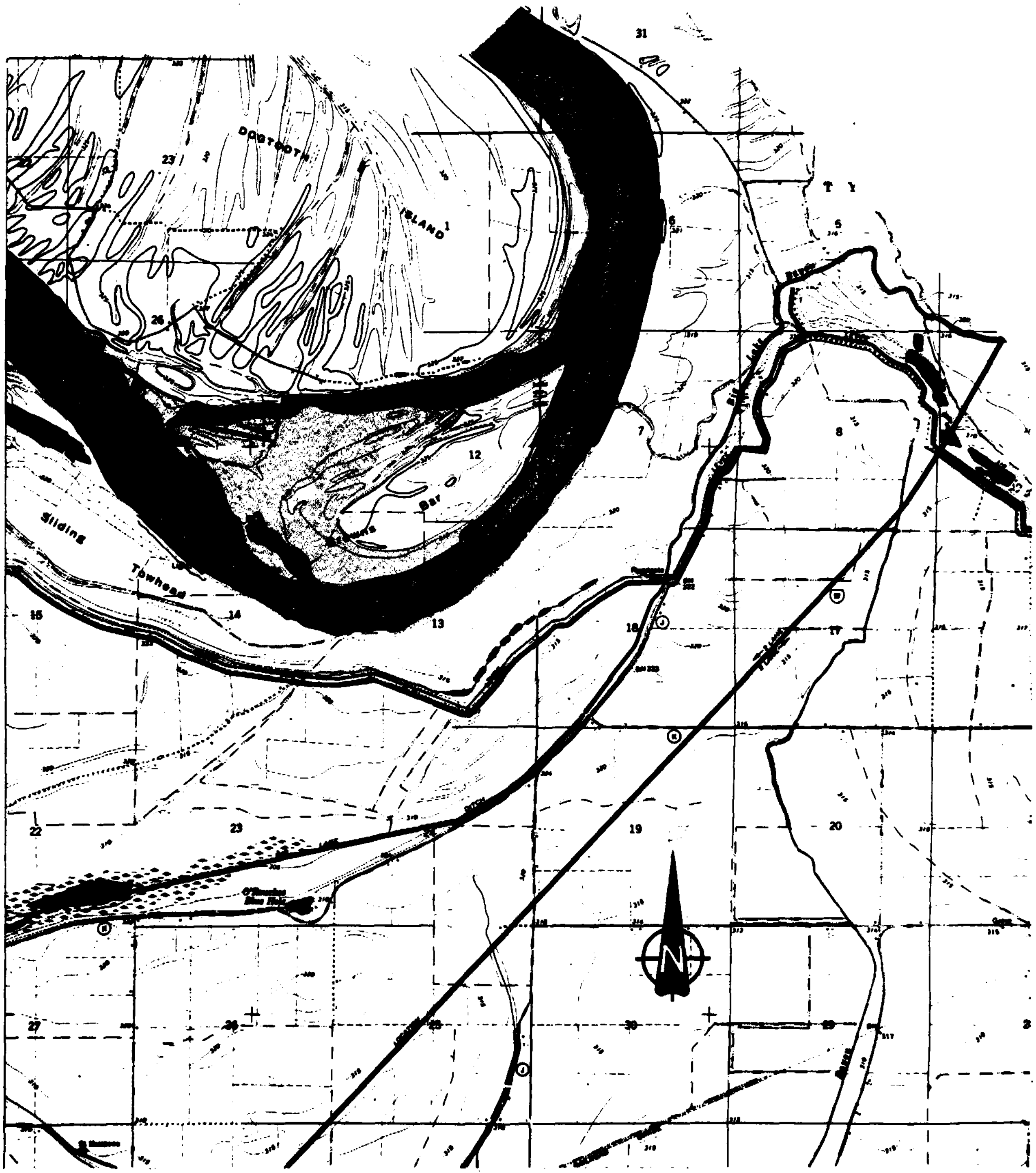

Figure 5-3
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 20-25.7
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

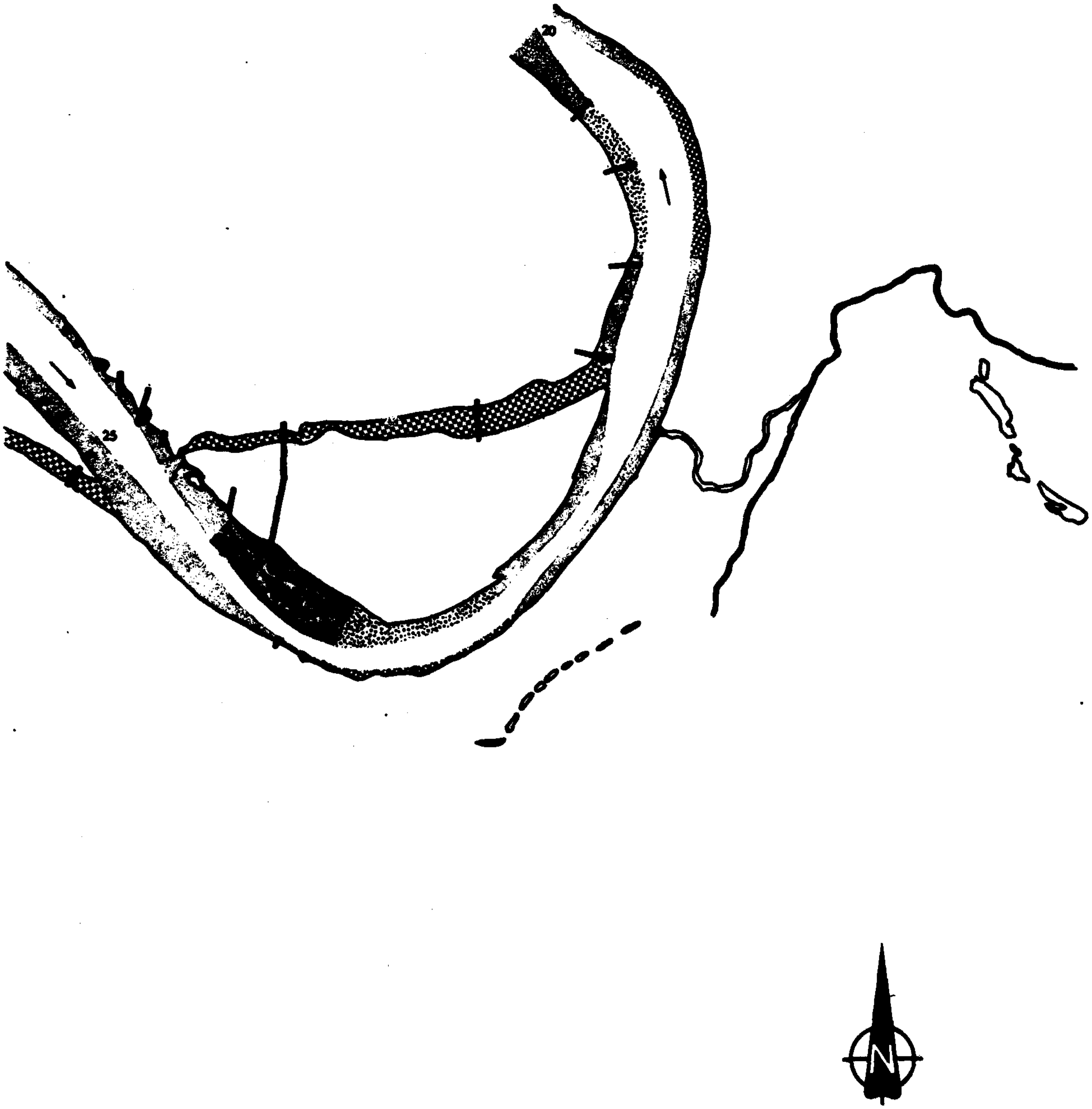

Figure 5-3
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 20-25.7
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

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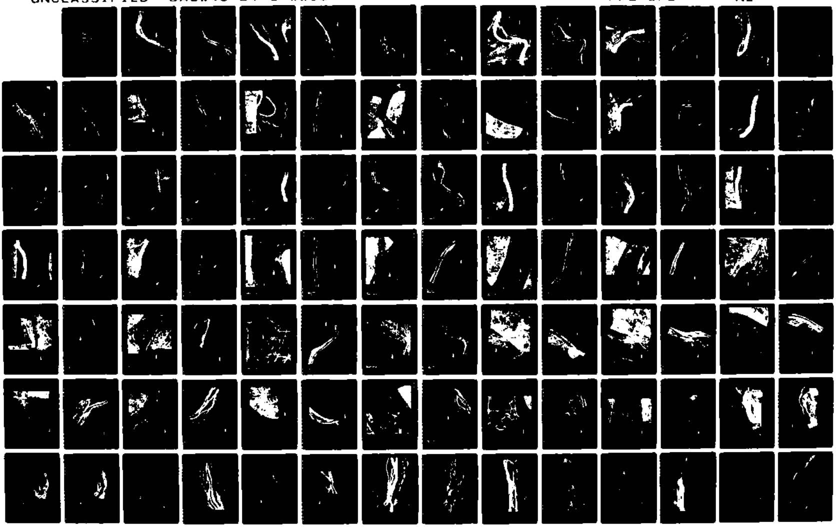

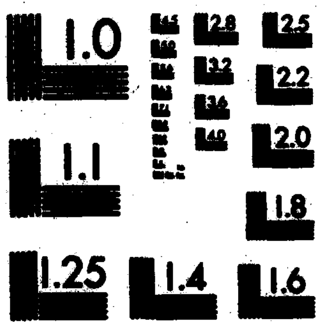

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

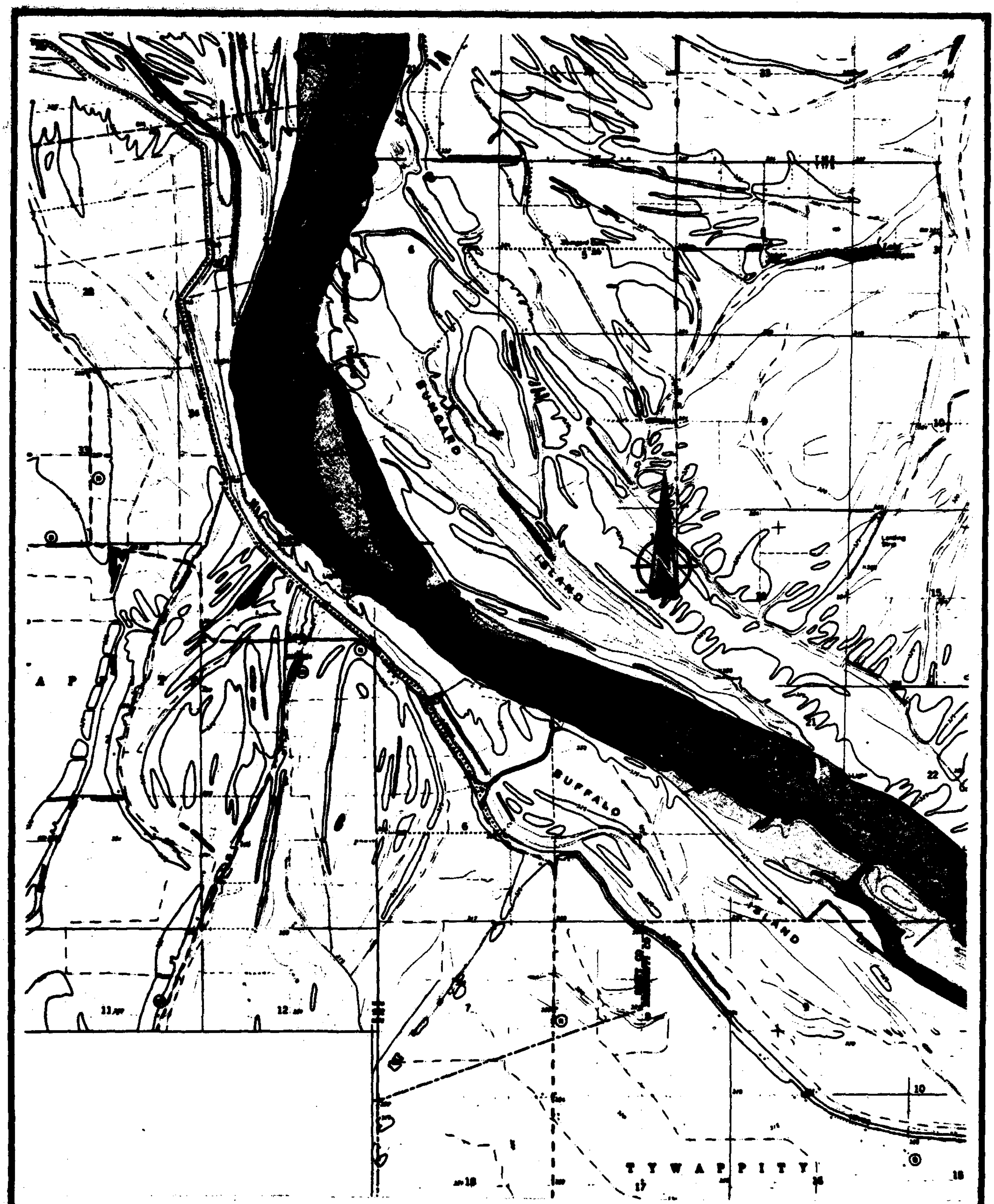

Figure 5-4
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 25.7-33
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

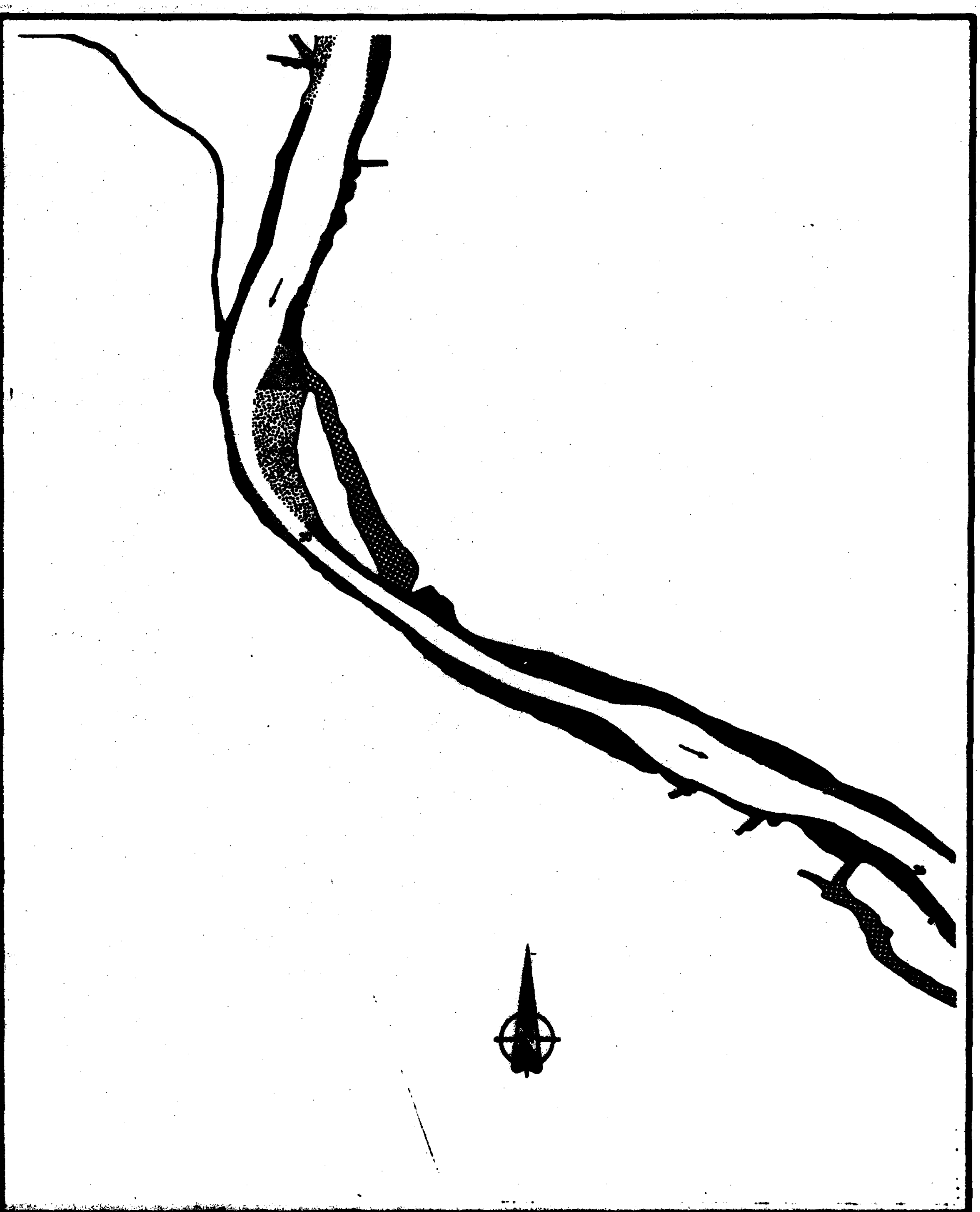

Figure 5-4
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 25.7-33
SOURCE: [illegible] INC., [illegible]

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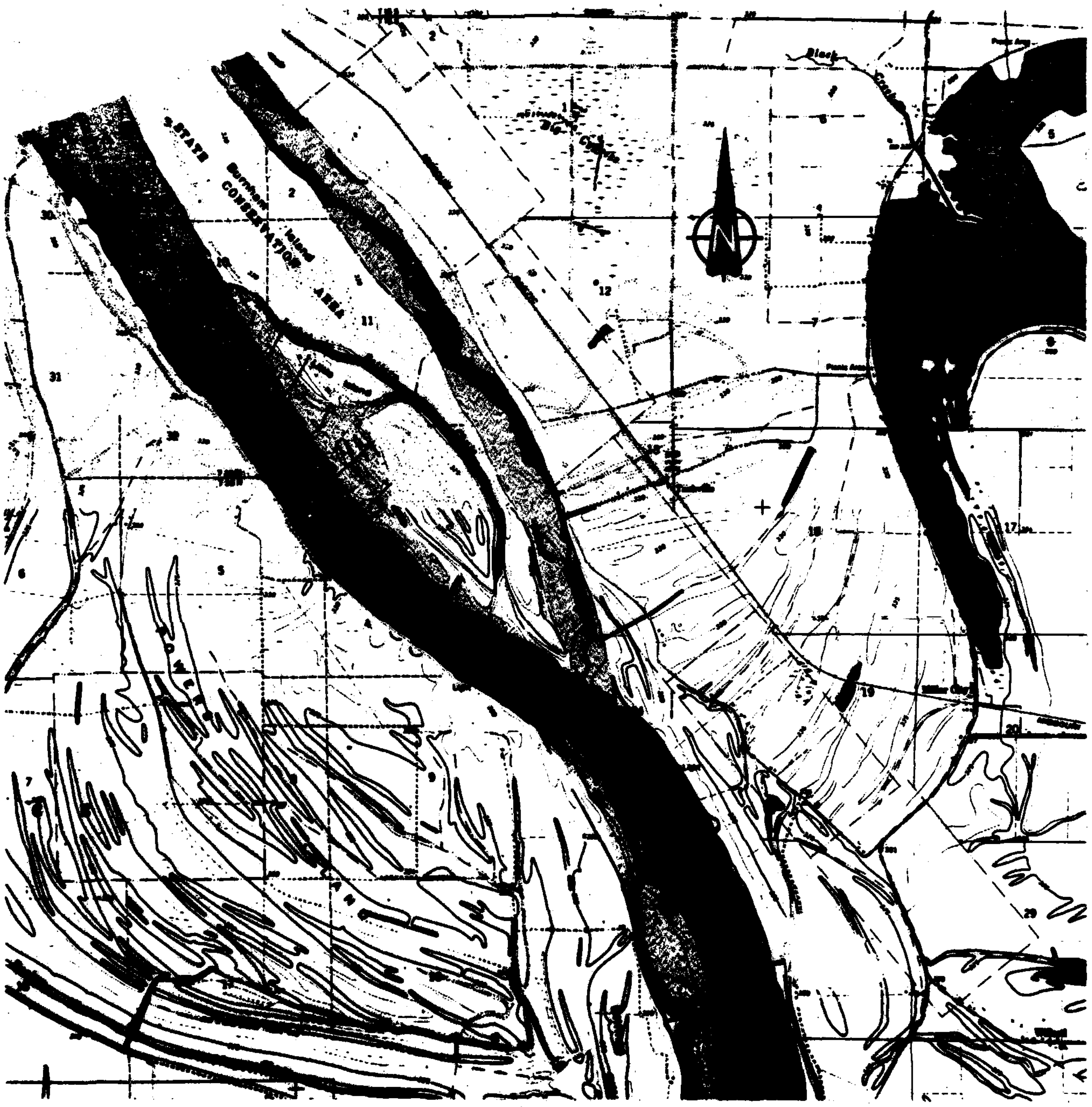

Figure 5-5
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 33-39
SOURCES: U.S. GEOLOGICAL SURVEY, 1975/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

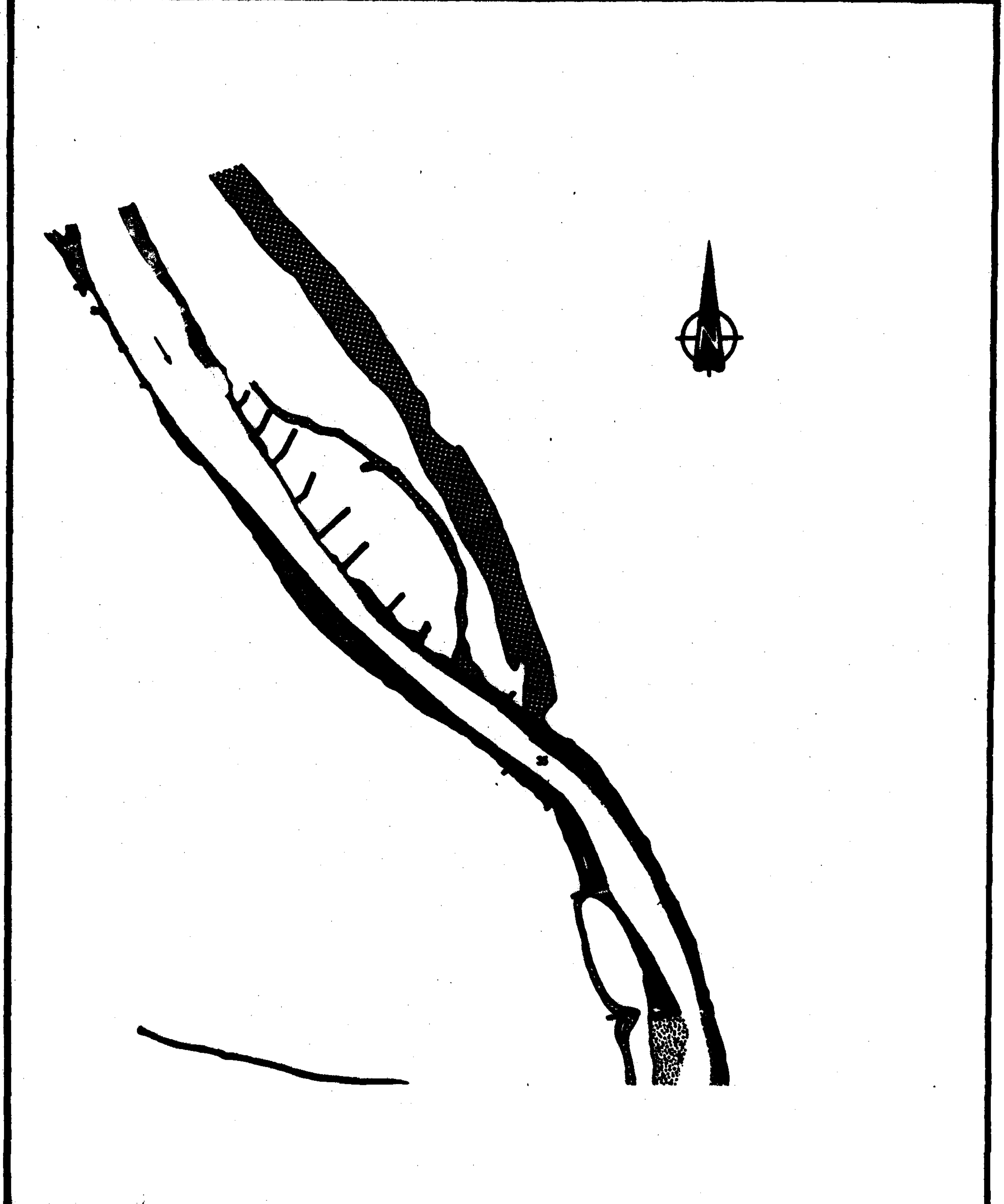

Figure 5-5
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 33-39
SOURCE: EDE INC., 1982

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Figure 5-6 **GEOPHYSICAL BASE MAP,** **MISSISSIPPI RIVER MILES 39-43** **SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982**	**GREAT III ECOLOGICAL CHARACTERIZATION** **St. Louis District Army Corps of Engineers**

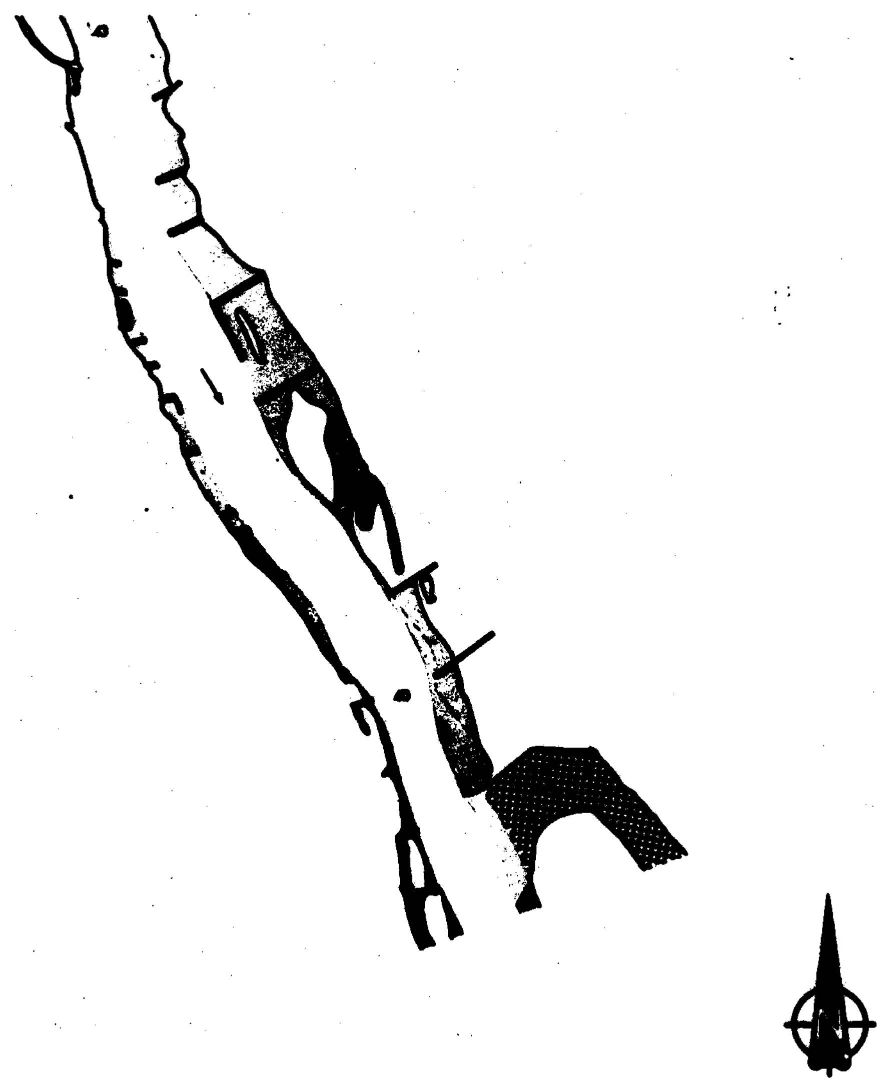

Figure 5-6
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 39-43
SOURCE: ESE INC., 1982

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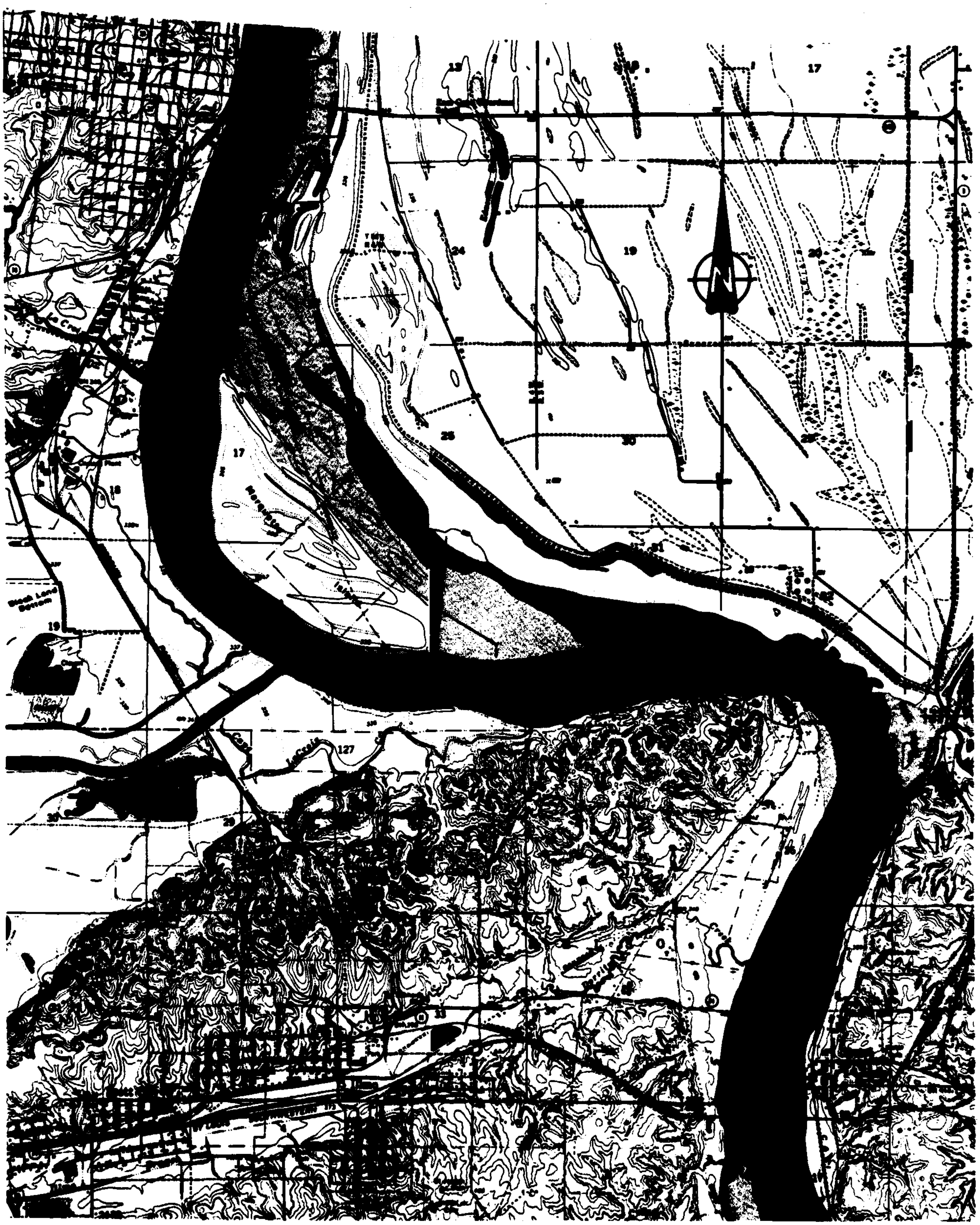

Figure 5-7
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 43-52

SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

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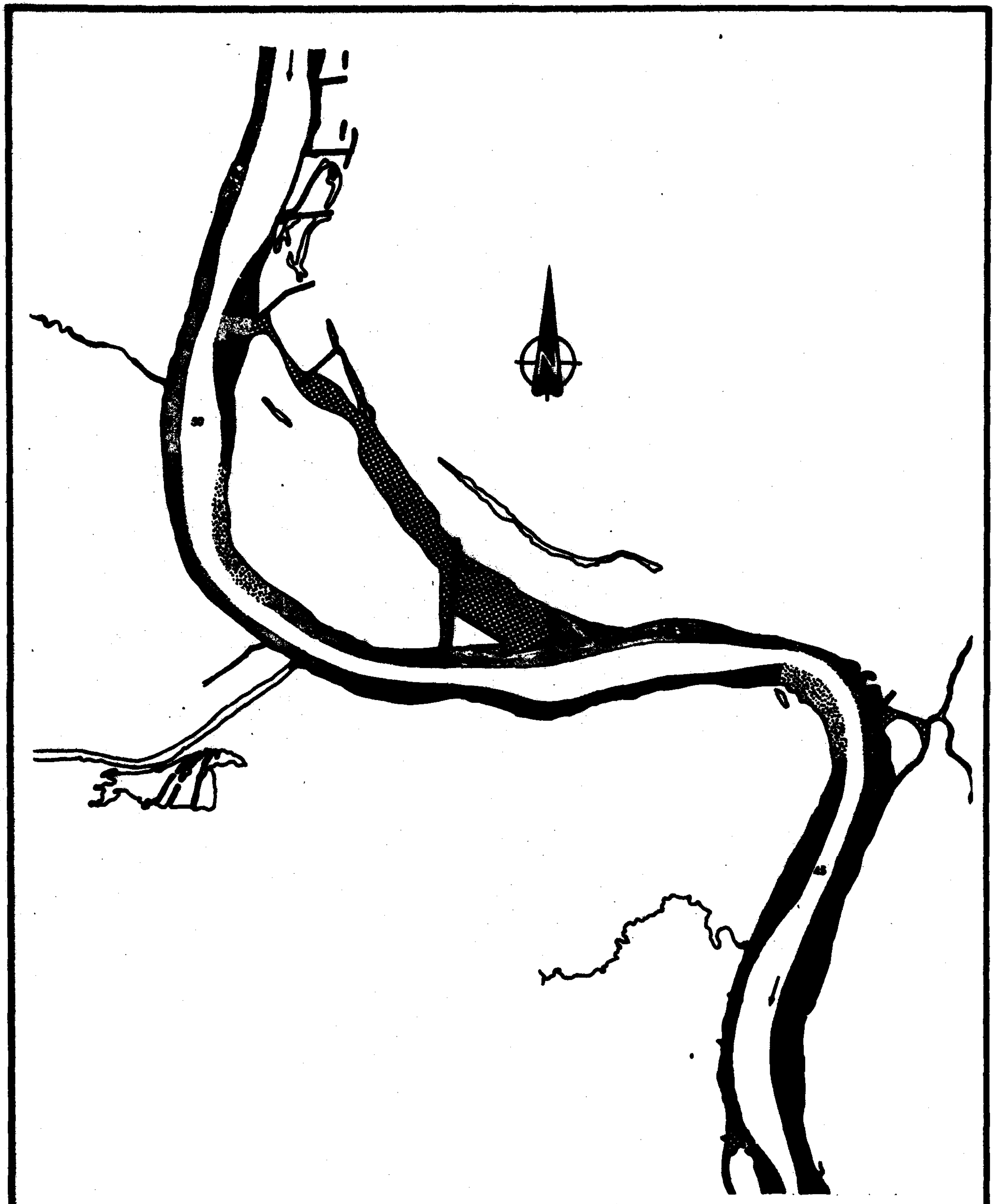

Figure 5-7
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 43-52
SOURCE: [illegible] INC., [illegible]

GREAT III ECOLOGICAL CHARACTERIZATION
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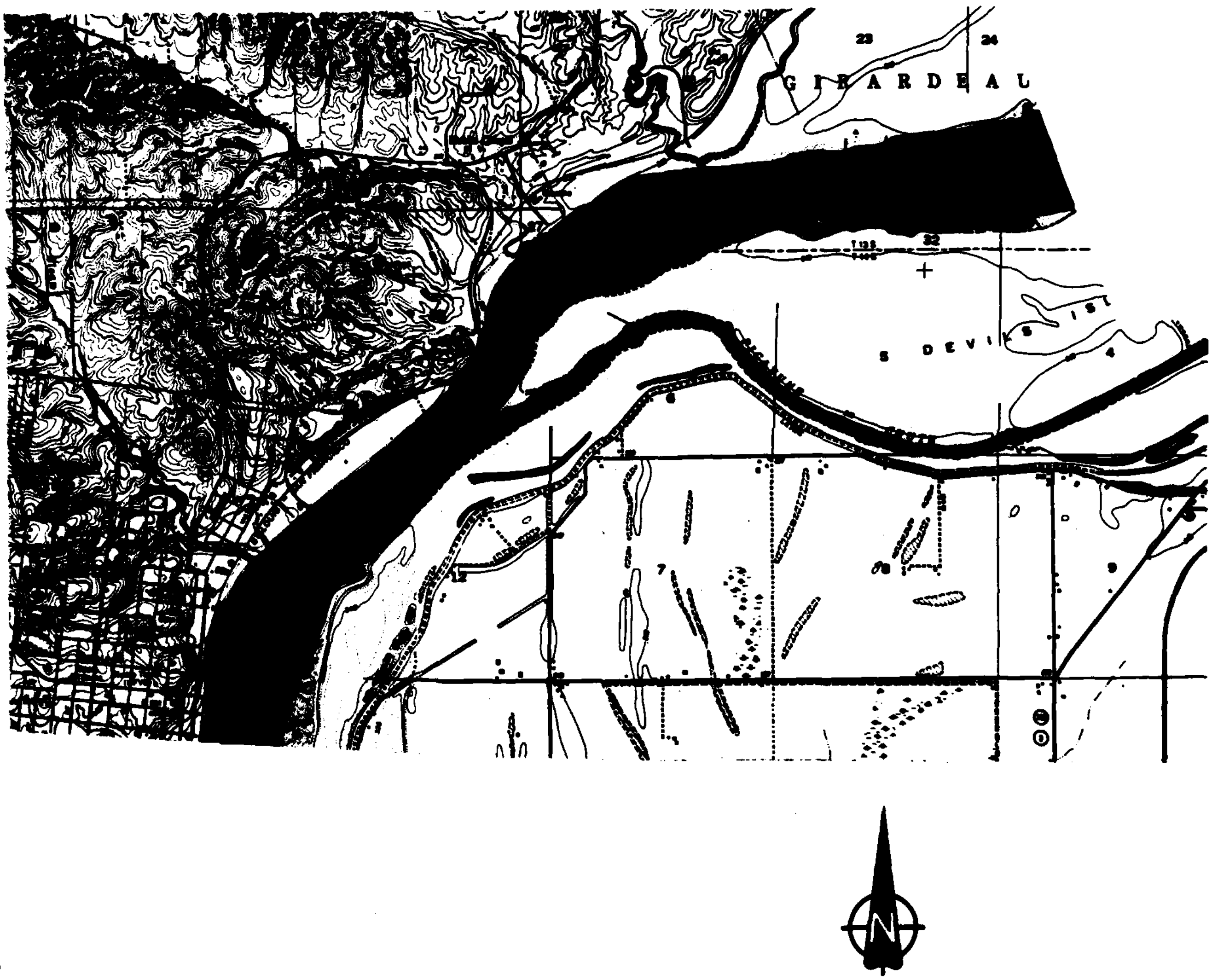

Figure 5-8
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 52-57
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

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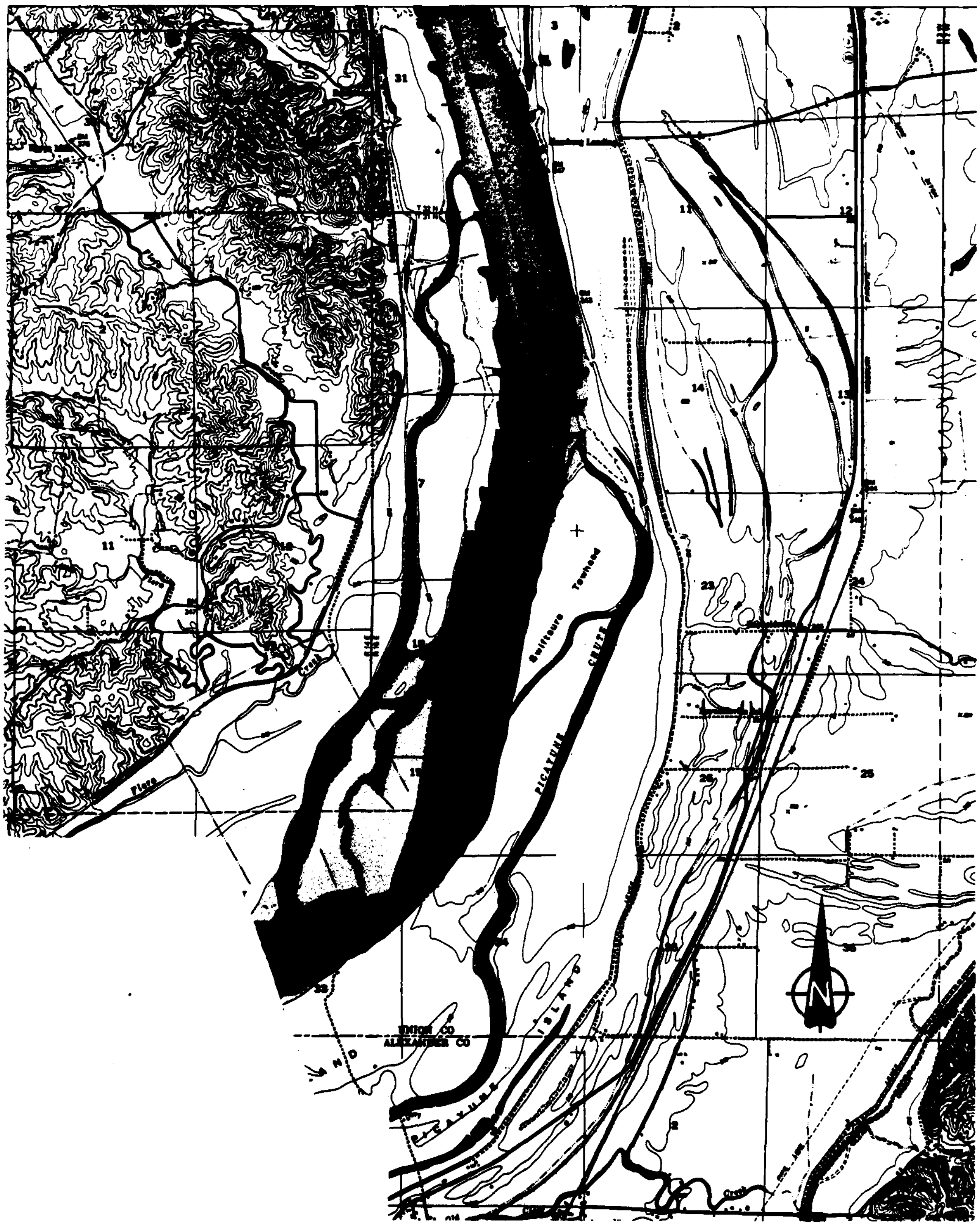

Figure 5-9
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 57-63.5
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 19[illegible]

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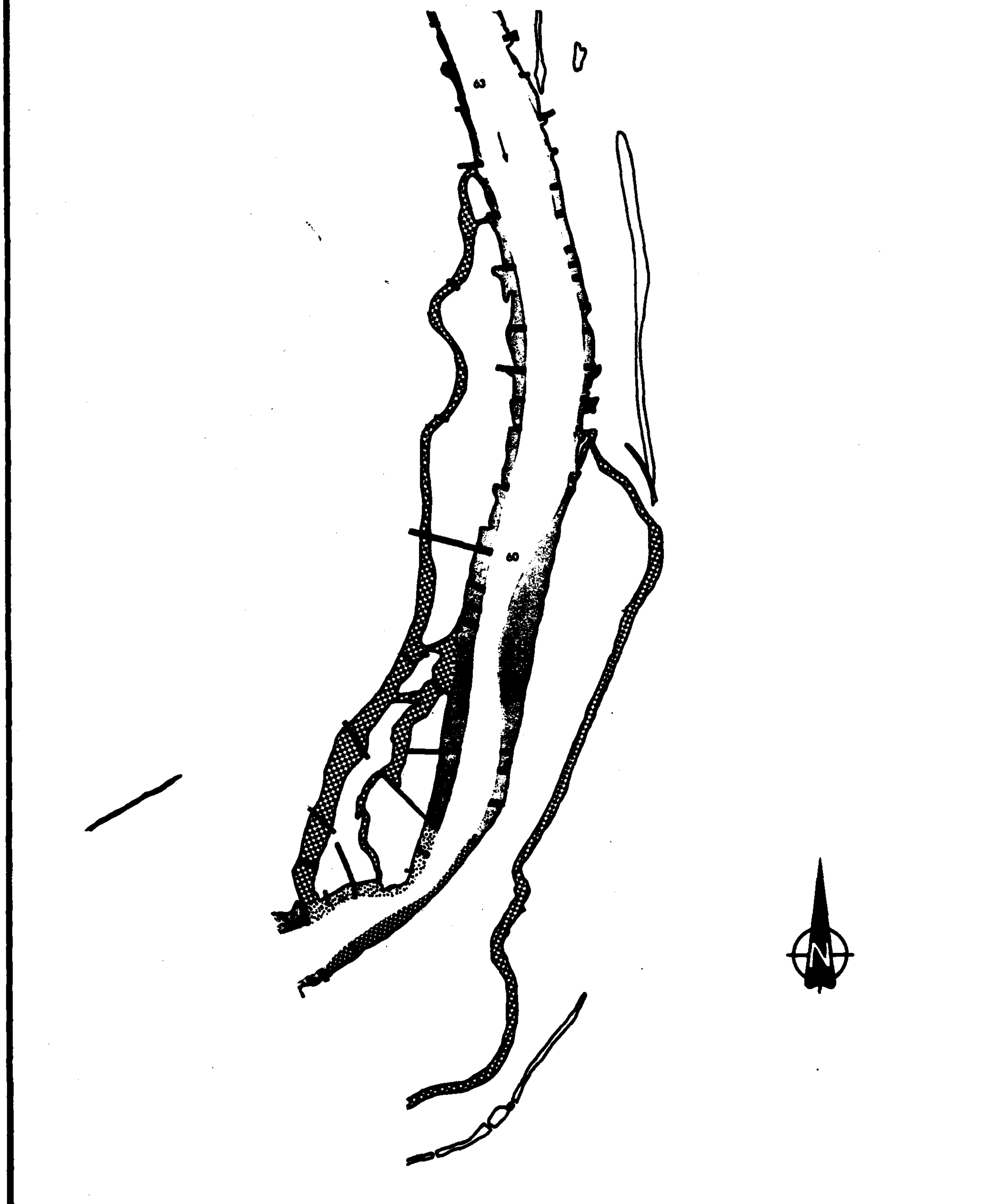

Figure 5-9
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 57-63.5
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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Figure 5-10
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 63.5-69
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

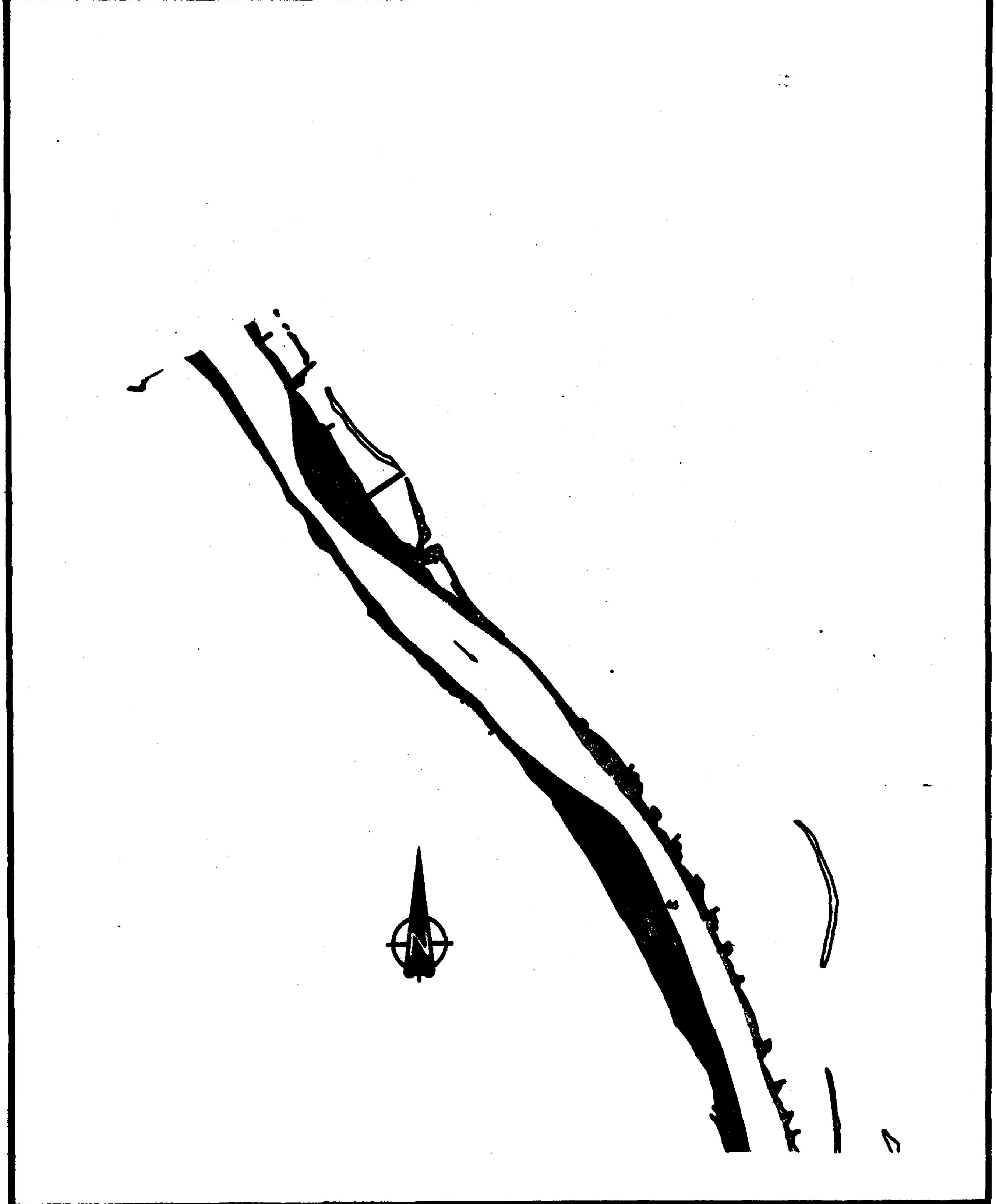

Figure 5-10
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 63.5-69
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

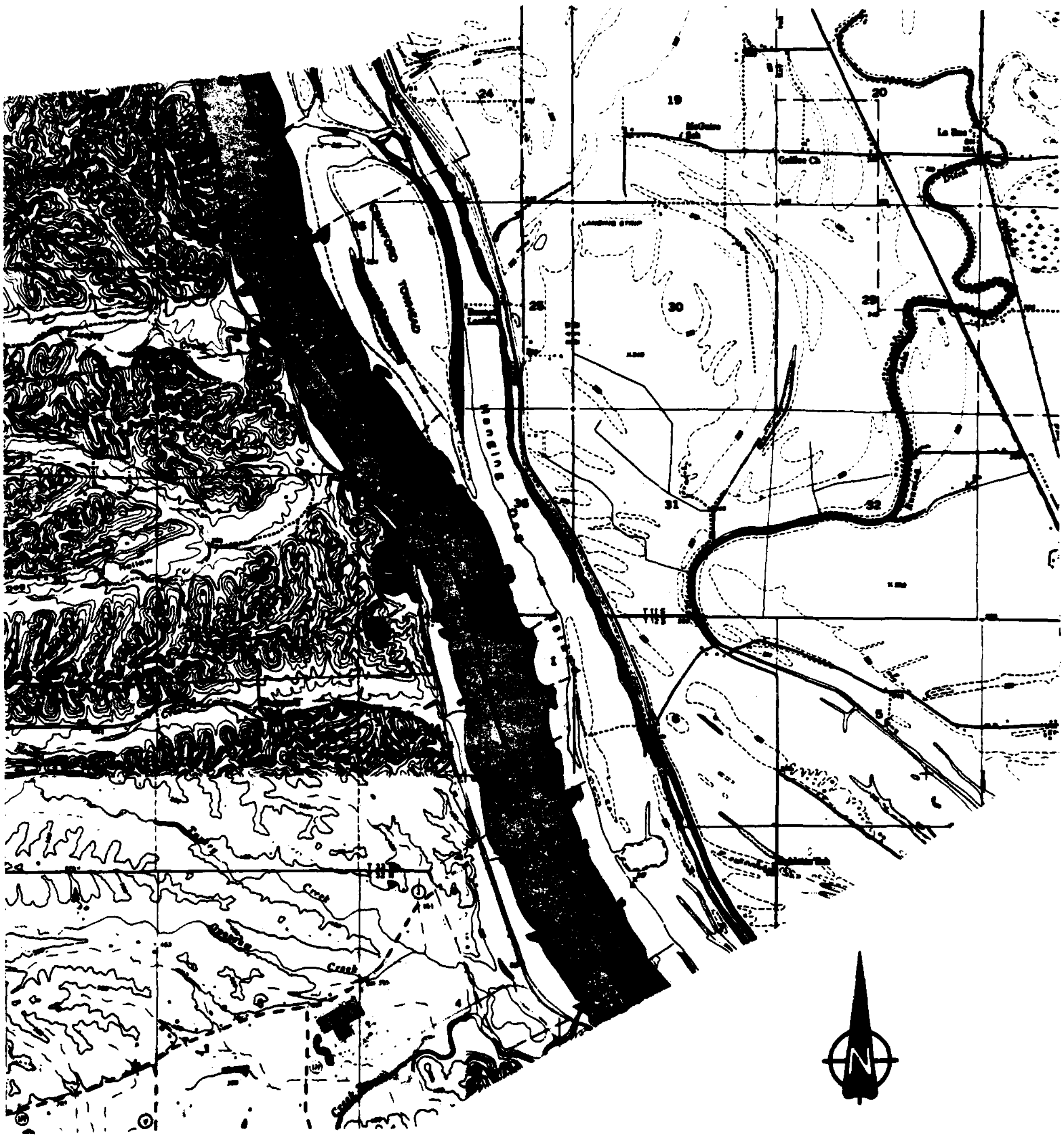

Figure 5-11 GEOPHYSICAL BASE MAP, MISSISSIPPI RIVER MILES 69-74 SOURCES: U.S. GEOLOGICAL SURVEY, 1979/ ESE, INC., 1982	GREAT III ECOLOGICAL CHARACTERIZATION St. Louis District Army Corps of Engineers

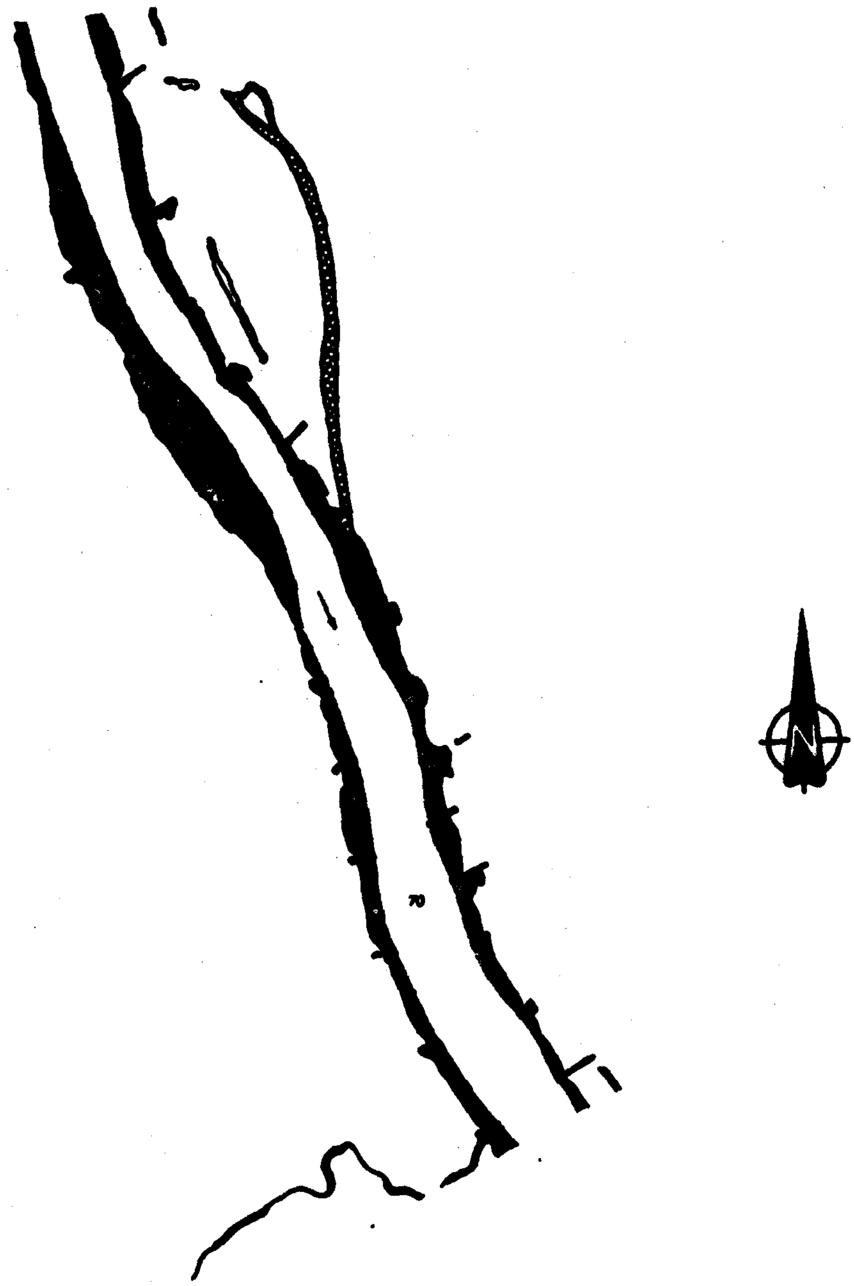

Figure 5-11
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 69-74
SOURCE: EBE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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Figure 5-12
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 74-79.5
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

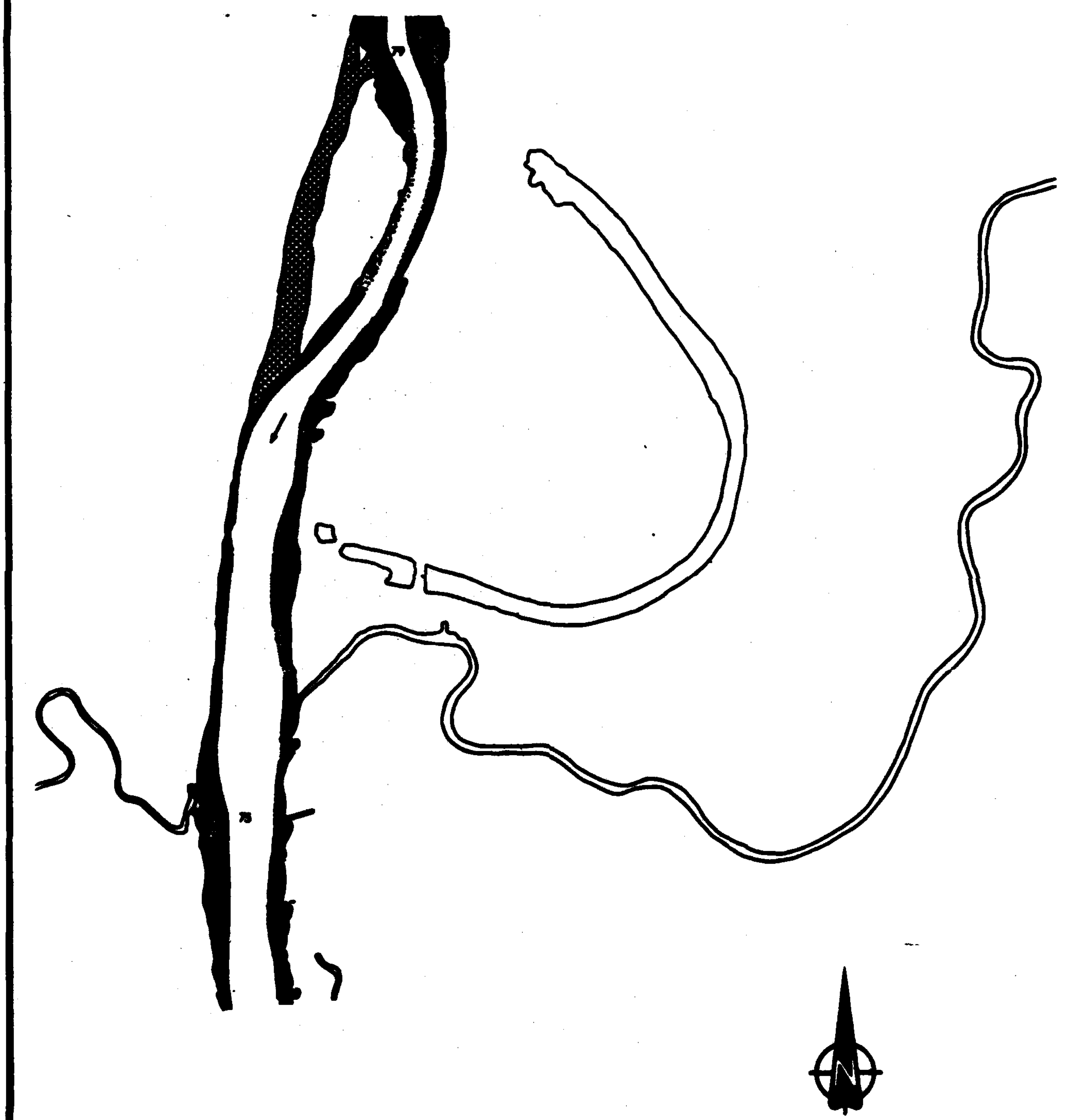

Figure 5-12
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 74-79.5
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-13
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 79.5-86
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ EDE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

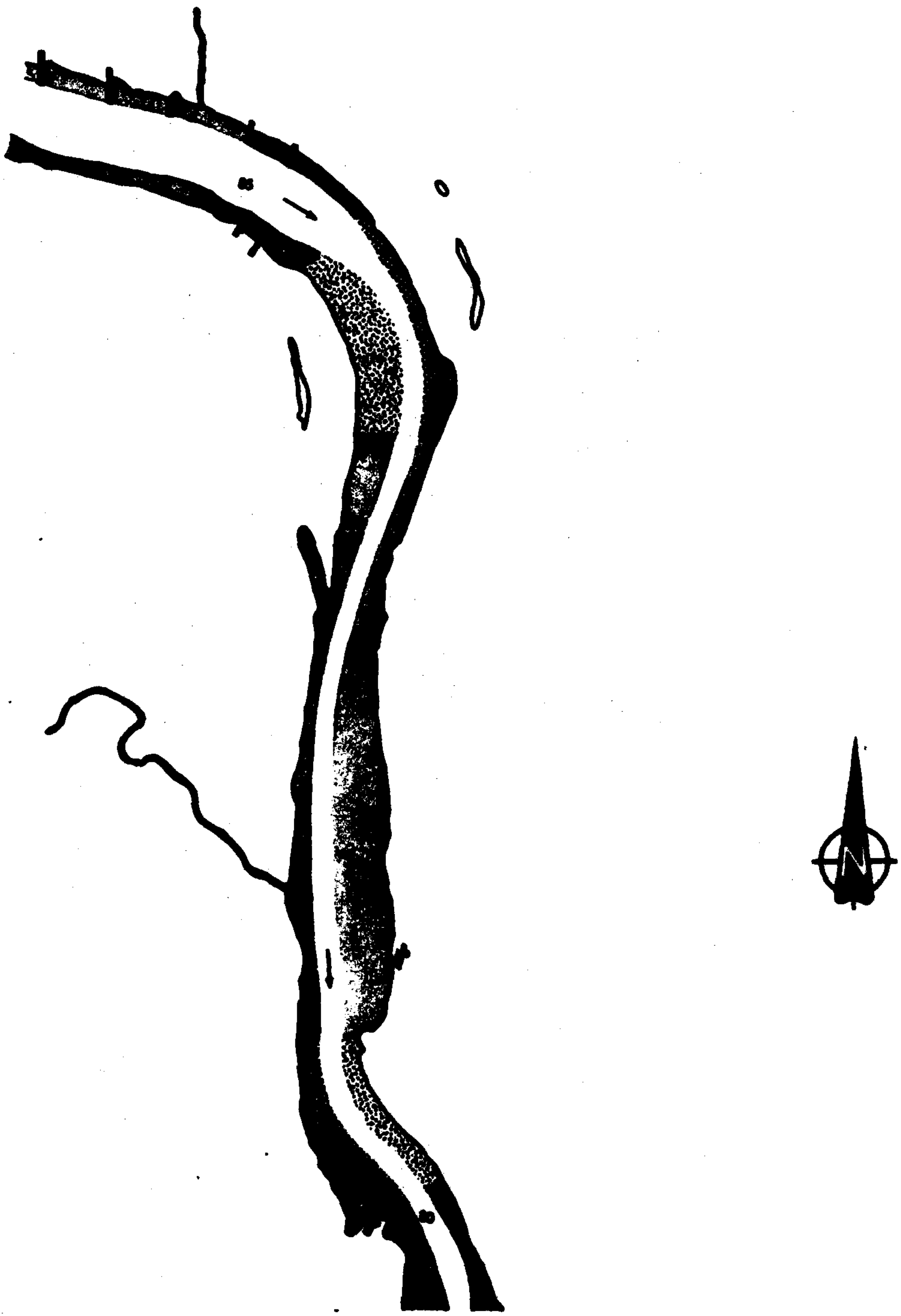

Figure 5-13
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 79.5-86
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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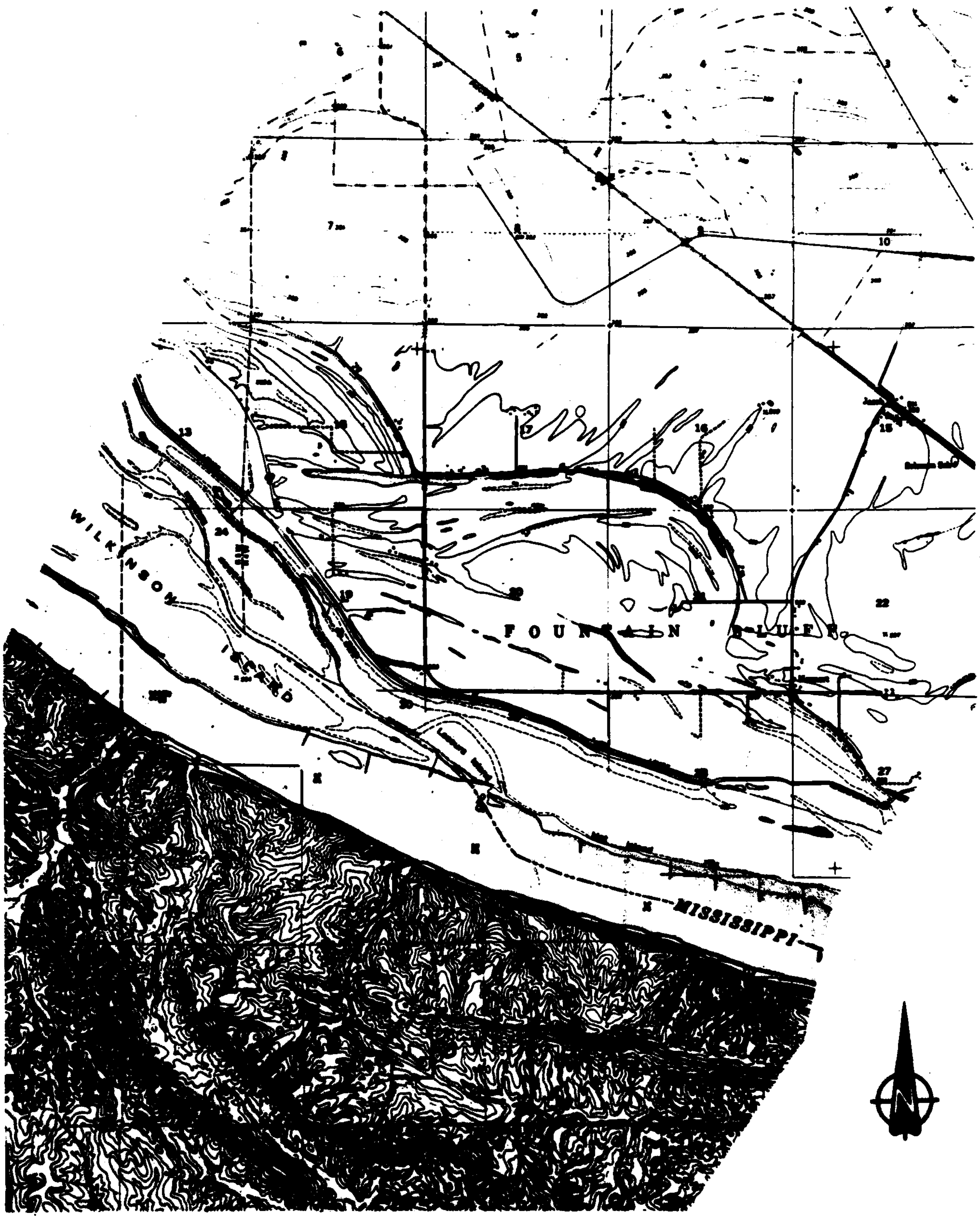

Figure 5-14 GEOPHYSICAL BASE MAP, MISSISSIPPI RIVER MILES 86-91 SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982	GREAT III ECOLOGICAL CHARACTERIZATION St. Louis District Army Corps of Engineers

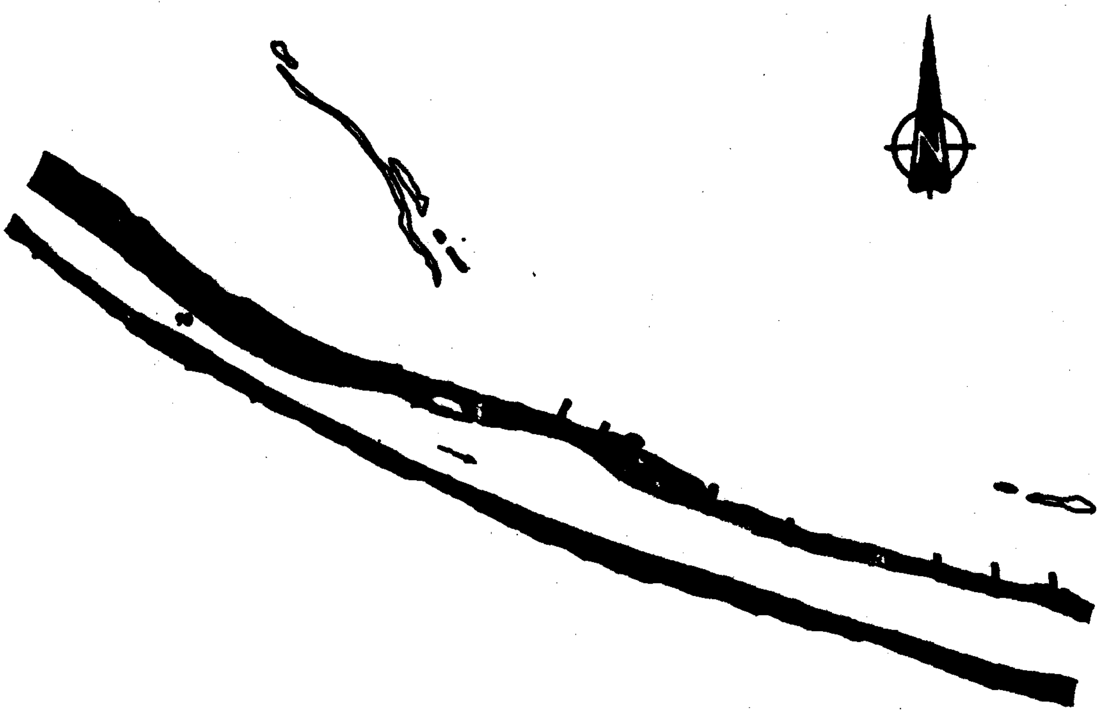

Figure 5-14
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 86-91
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-15
GEOPHYSICAL BASE MAP, MISSISSIPPI RIVER MILES 91-96
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

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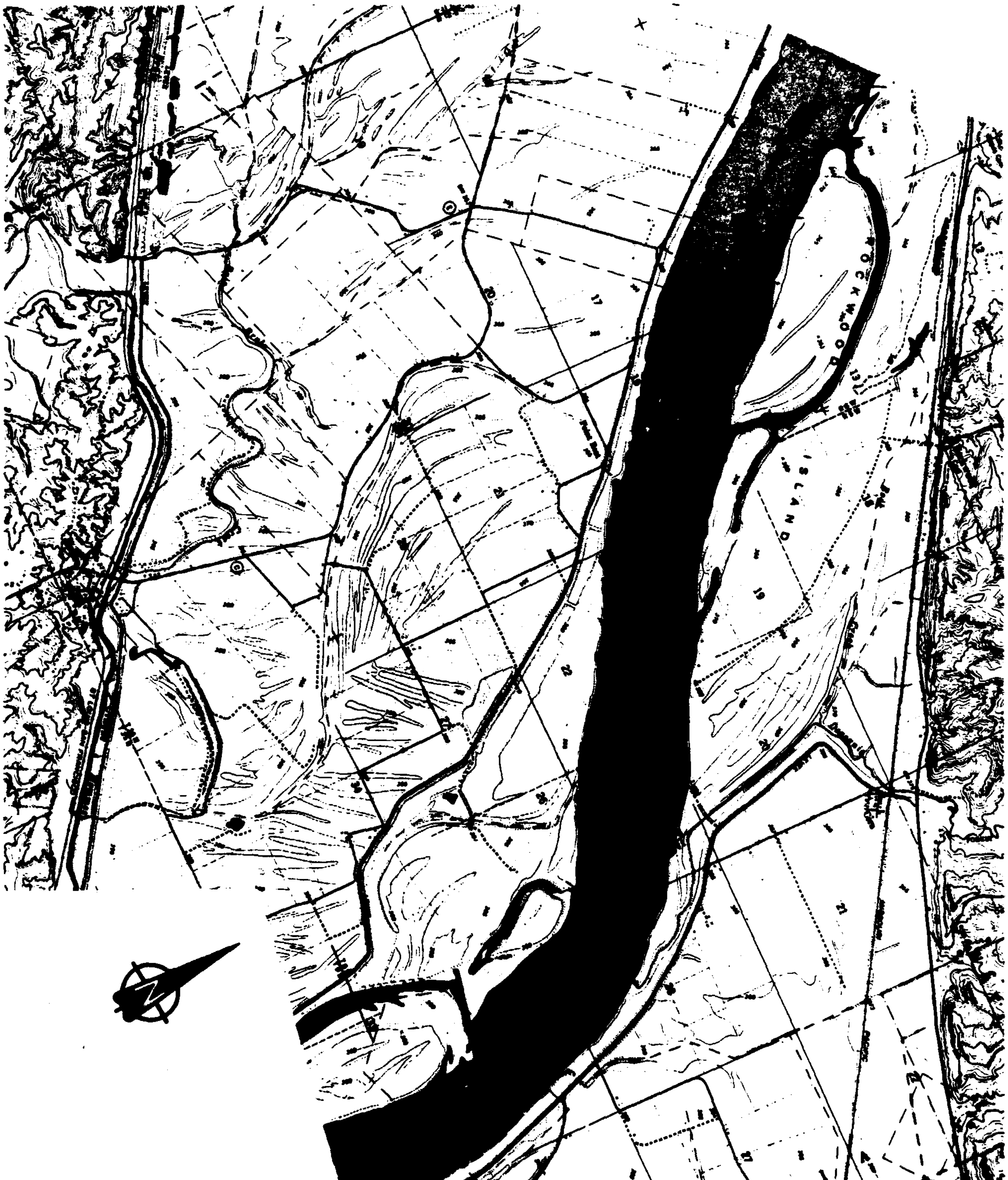

Figure 5-16
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 96-103
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

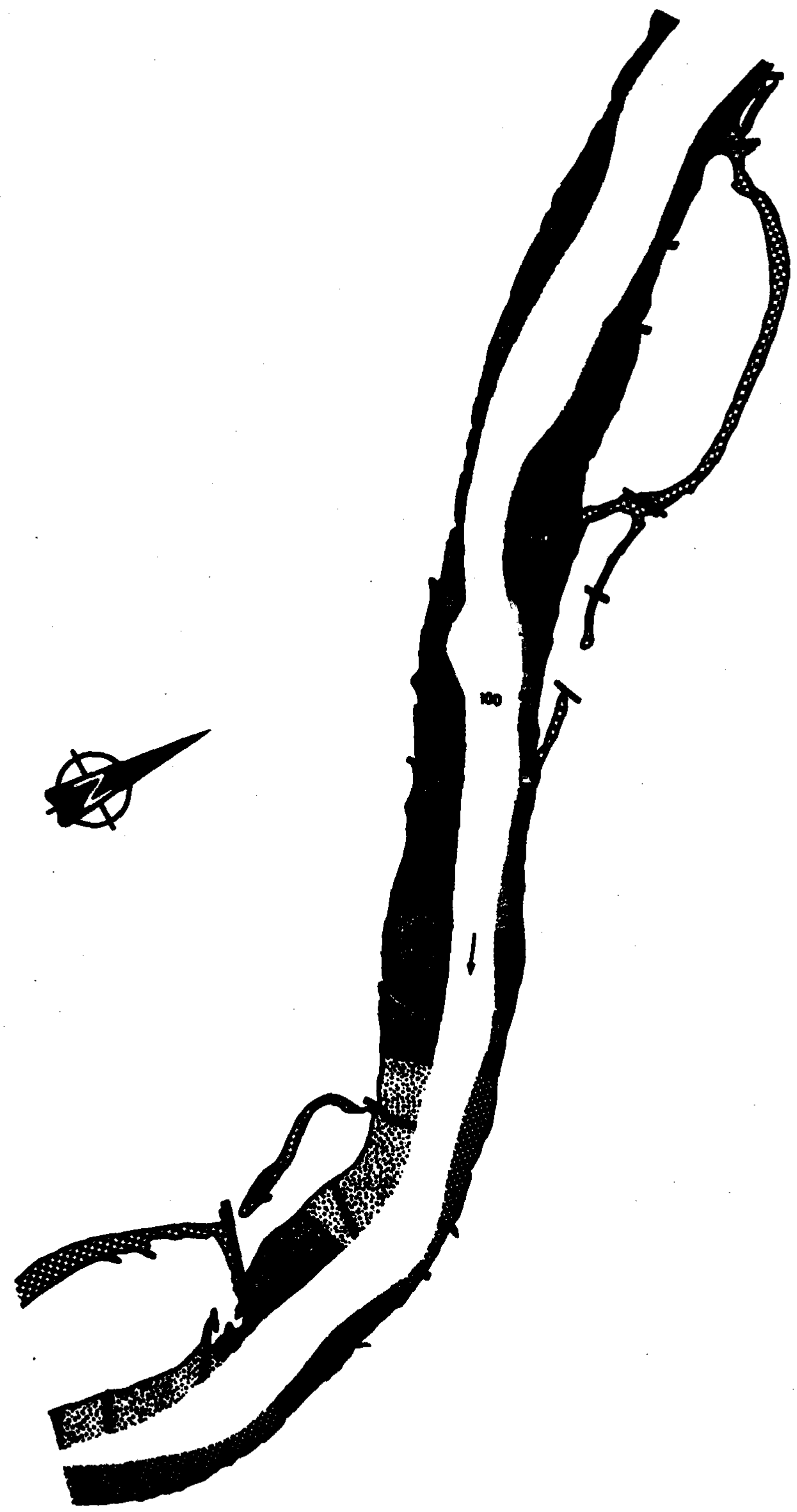

Figure 5-16 AQUATIC HABITATS, MISSISSIPPI RIVER MILES 96-103 SOURCE: ESE INC., 1982	GREAT III ECOLOGICAL CHARACTERIZATION St. Louis District Army Corps of Engineers

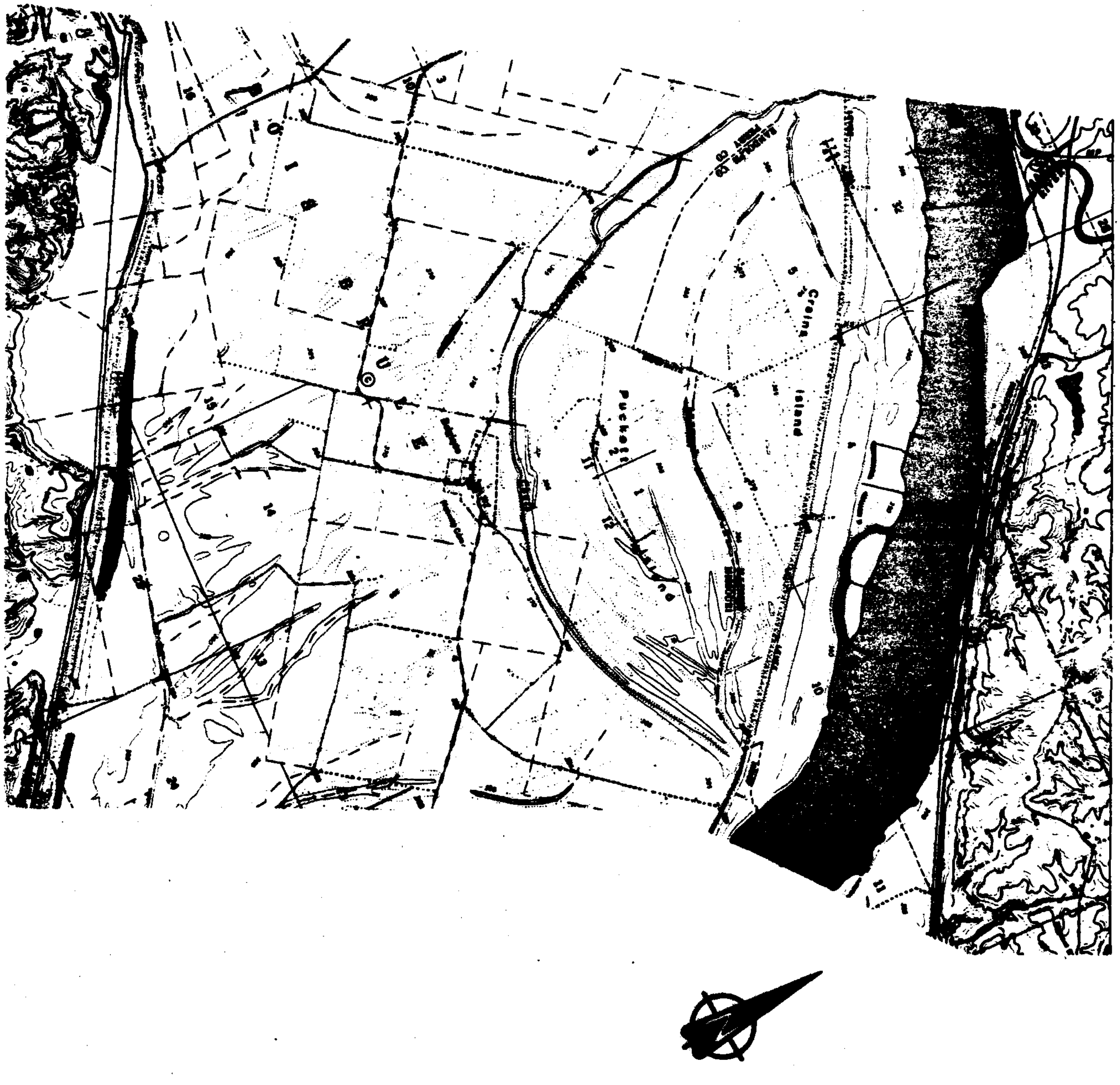

Figure 5-17
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 103-107
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

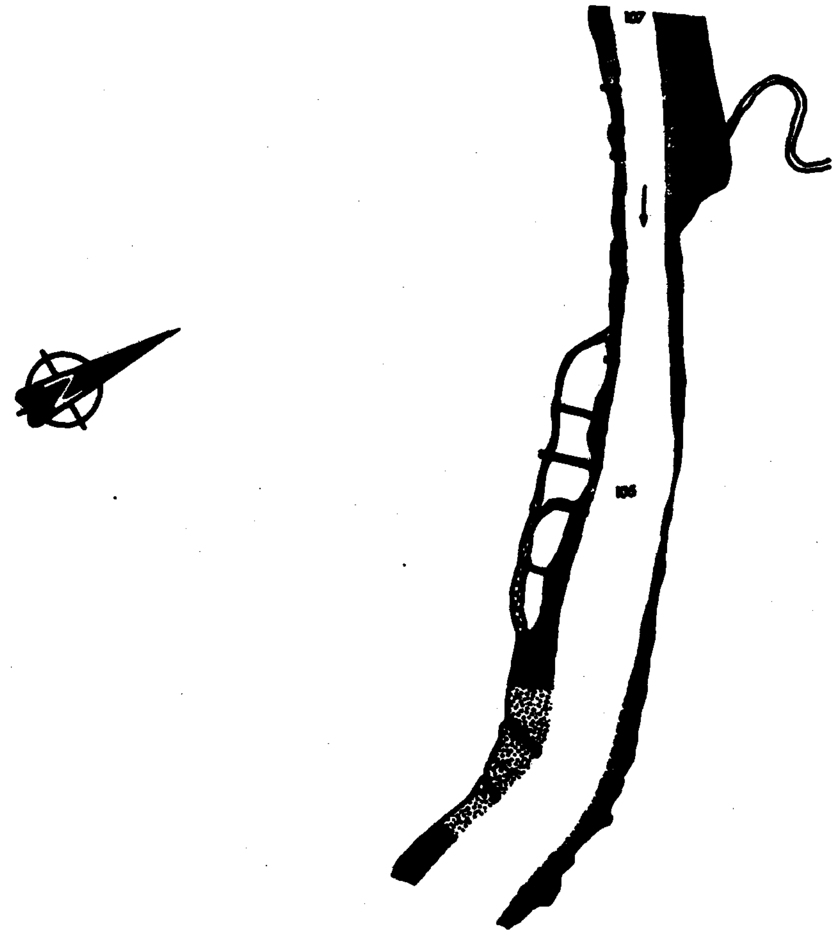

Figure 5-17
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 103-107
SOURCE: ESE INC., 1982

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St. Louis District Army Corps of Engineers

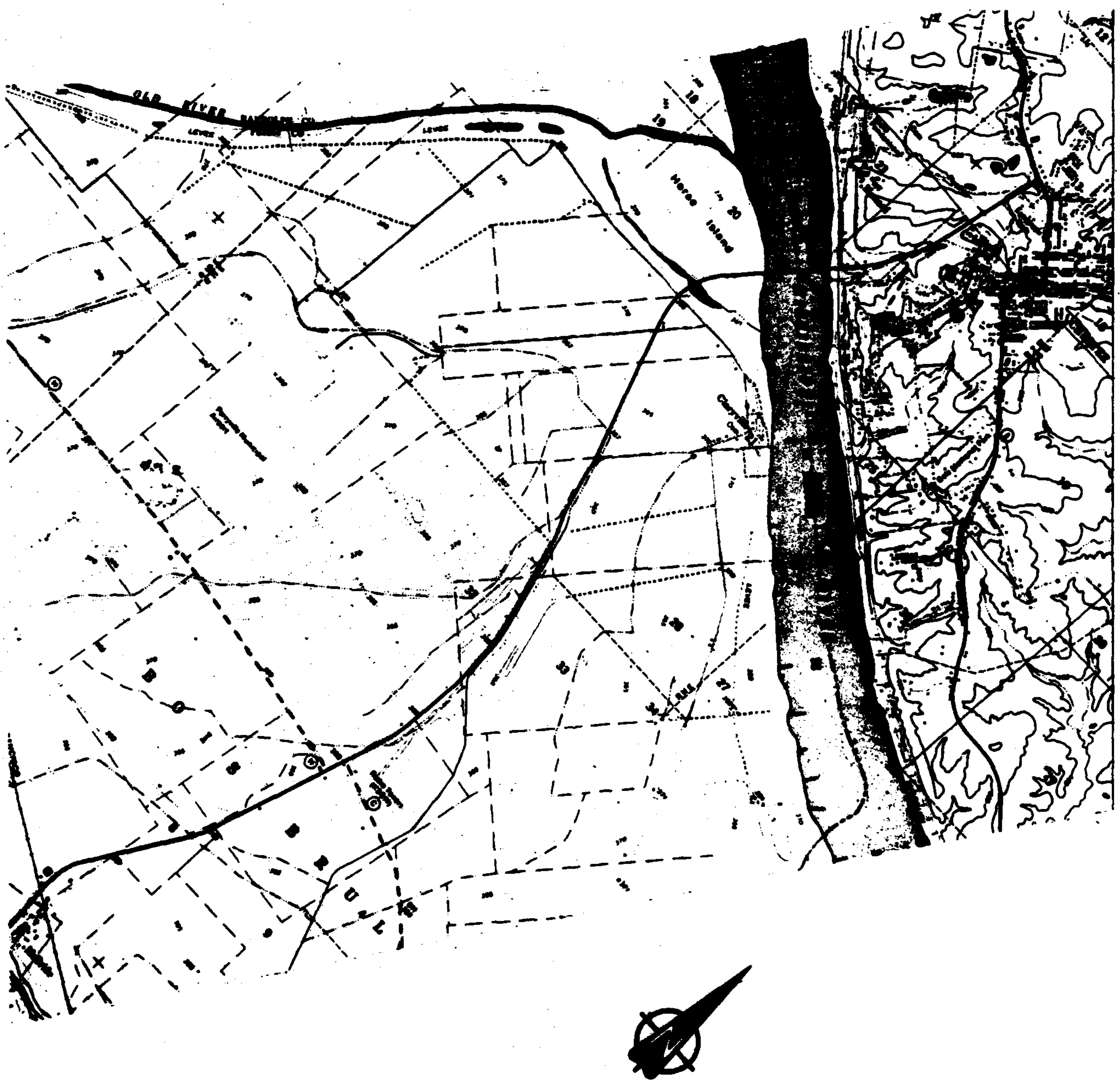

Figure 5-18
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 107-111
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

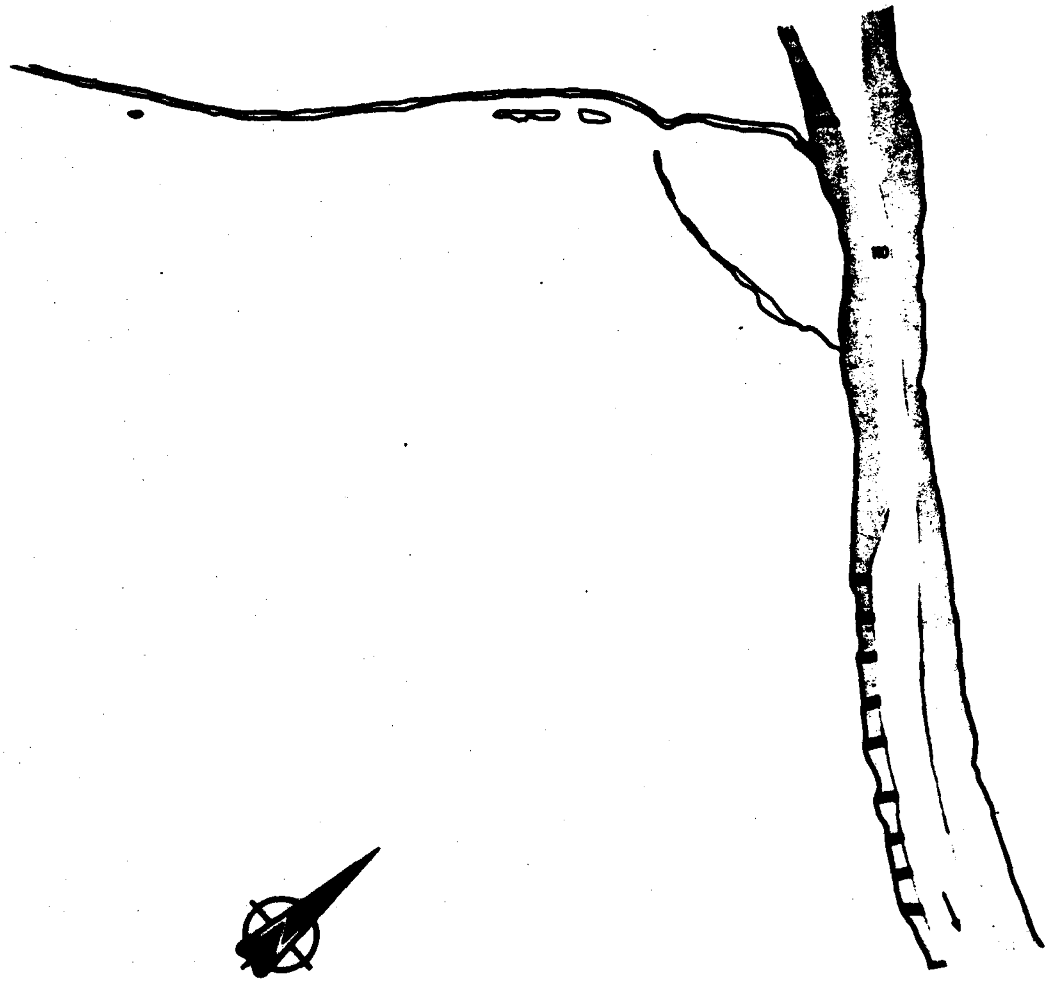

Figure 5-18
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 107-111
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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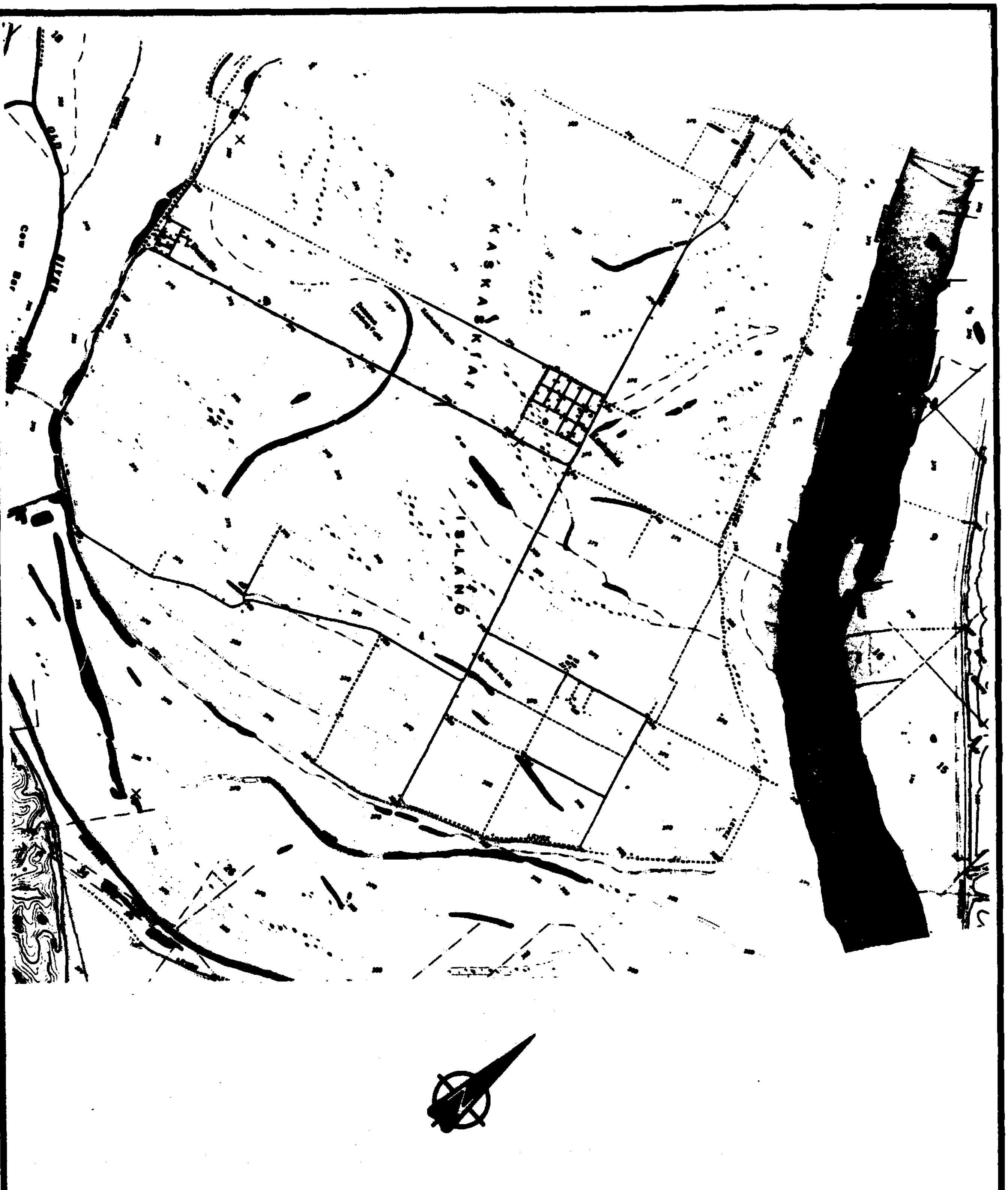

Figure 5-19
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 111-115.5
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-19
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 111-115.5
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

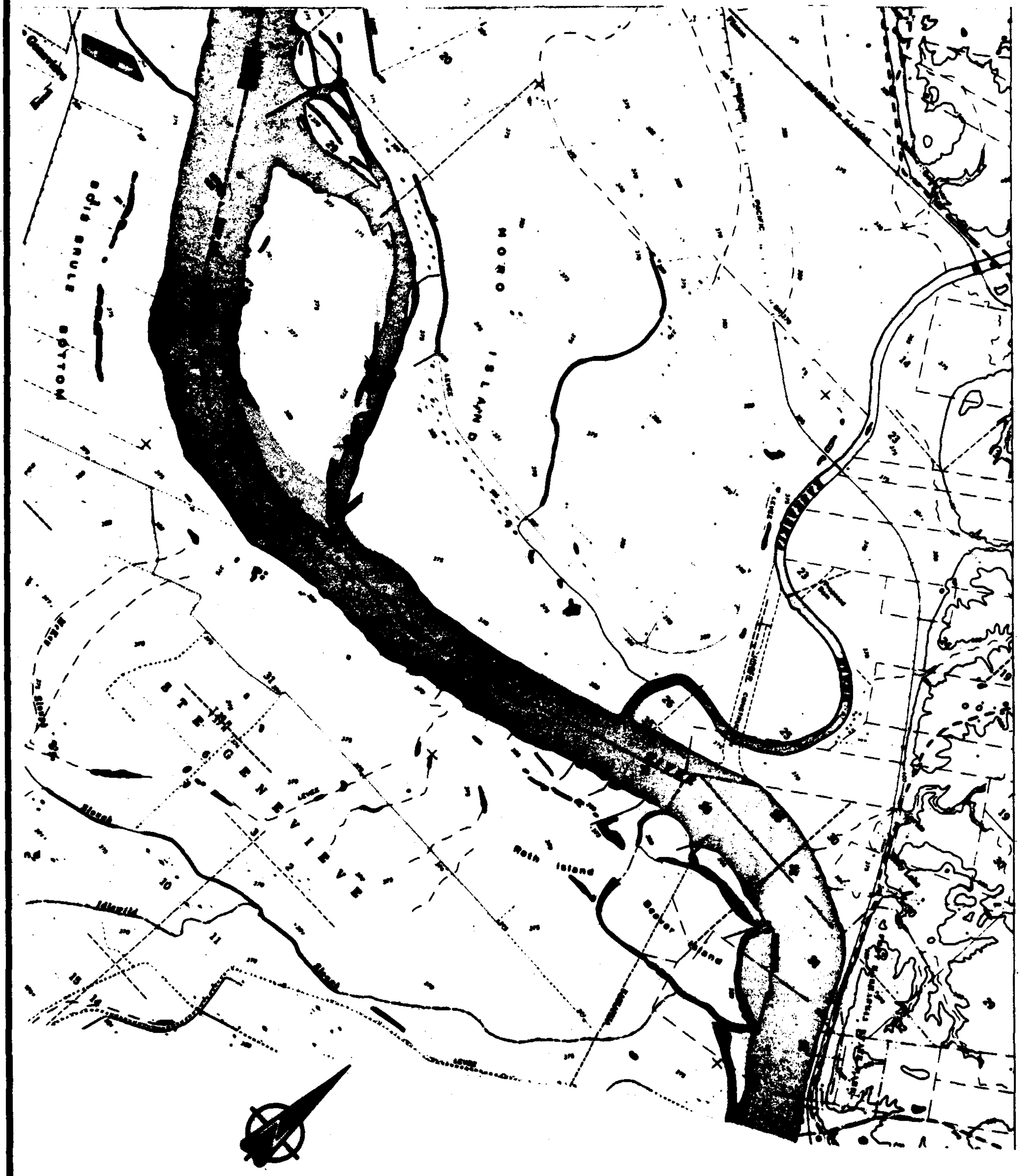

Figure 5-20
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 115.5-123
SOURCES: U.S. GEOLOGICAL SURVEY, 1976 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

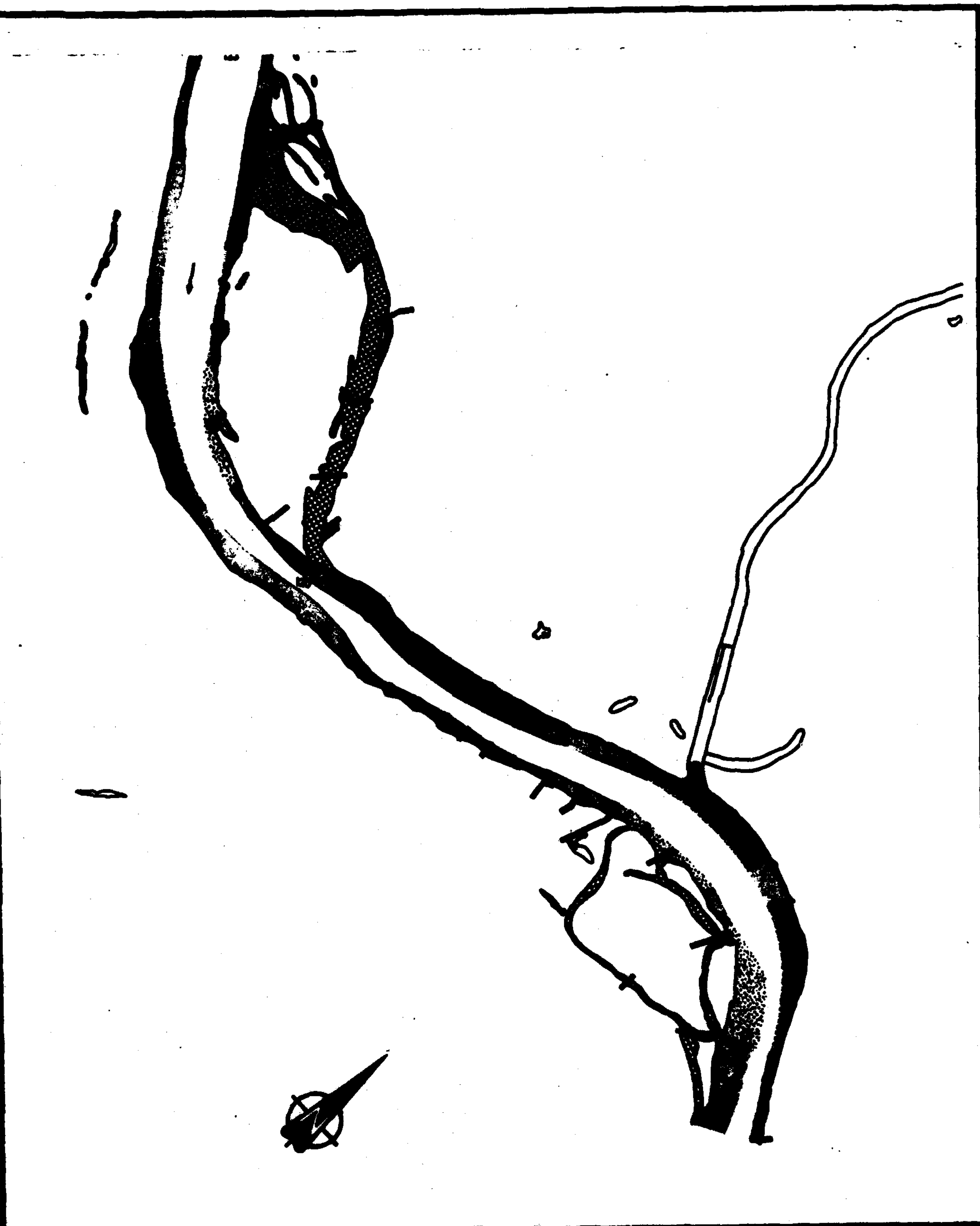

Figure 5-20
AQUATIC HABITATS.
MISSISSIPPI RIVER MILES 115.5-123
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

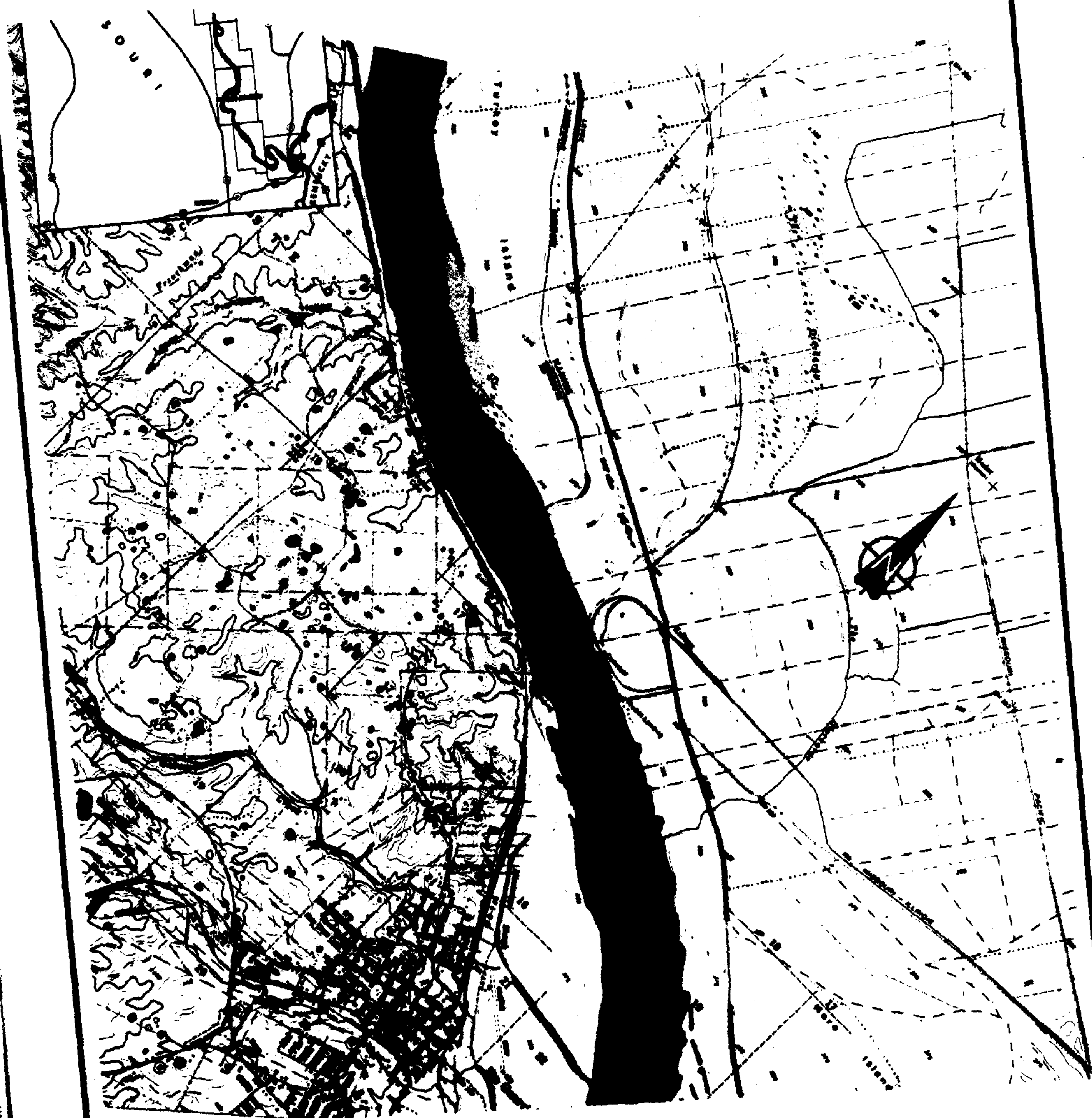

Figure 5-21
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 123-129
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

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St. Louis District Army Corps of Engineers

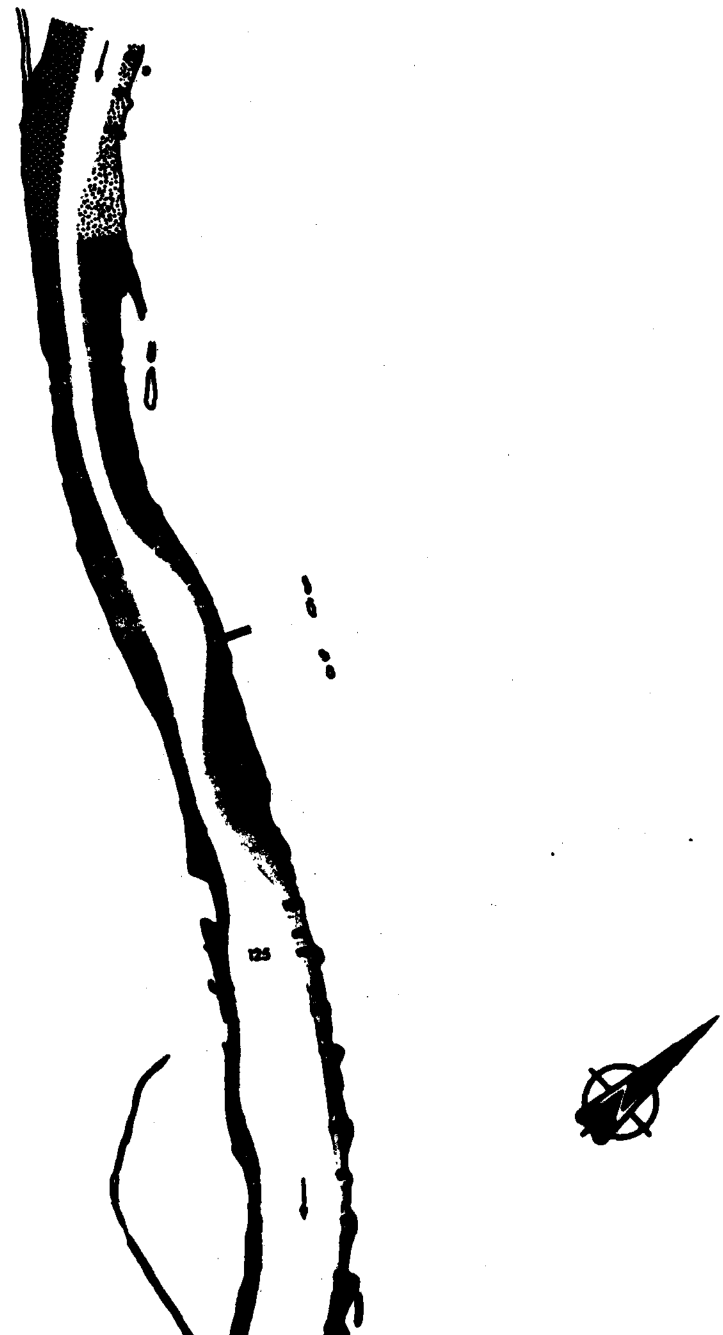

Figure 5-21
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 123-129
SOURCE: ESE INC., 1982

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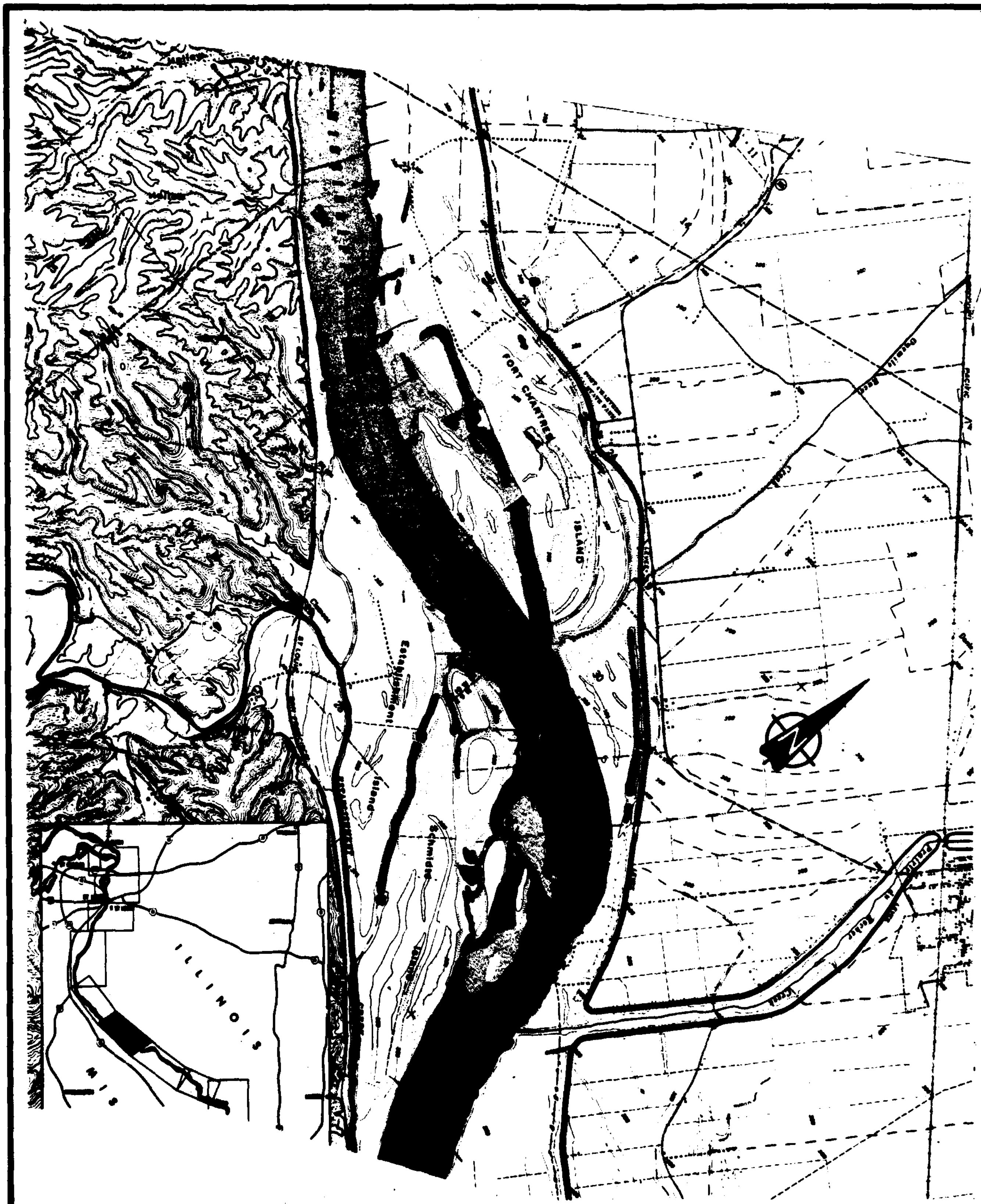

Figure 5-22
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 129-135.9
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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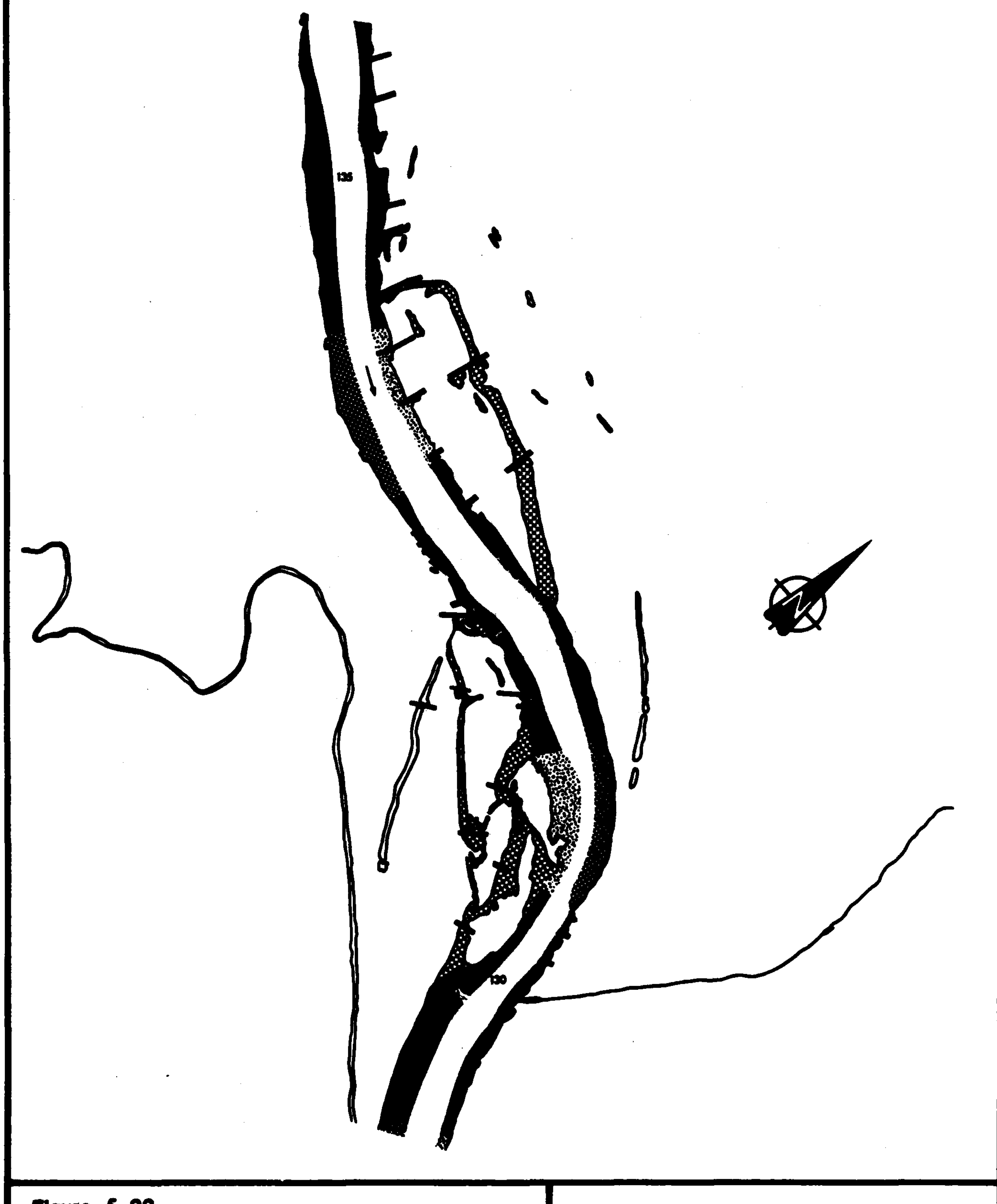

Figure 5-22
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 129-135.9
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-23
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 135.9-141
SOURCES: U.S. GEOLOGICAL SURVEY, 1975 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

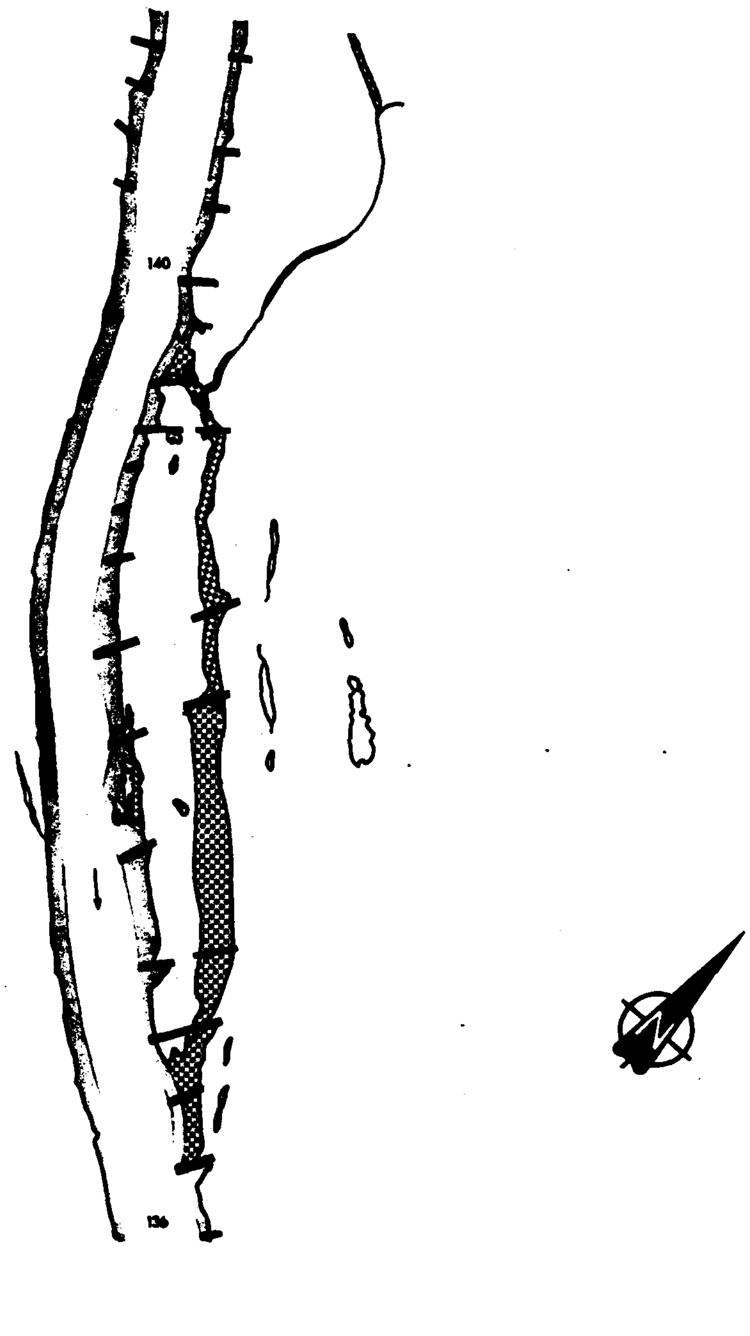

Figure 5-23
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 135.9-141
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

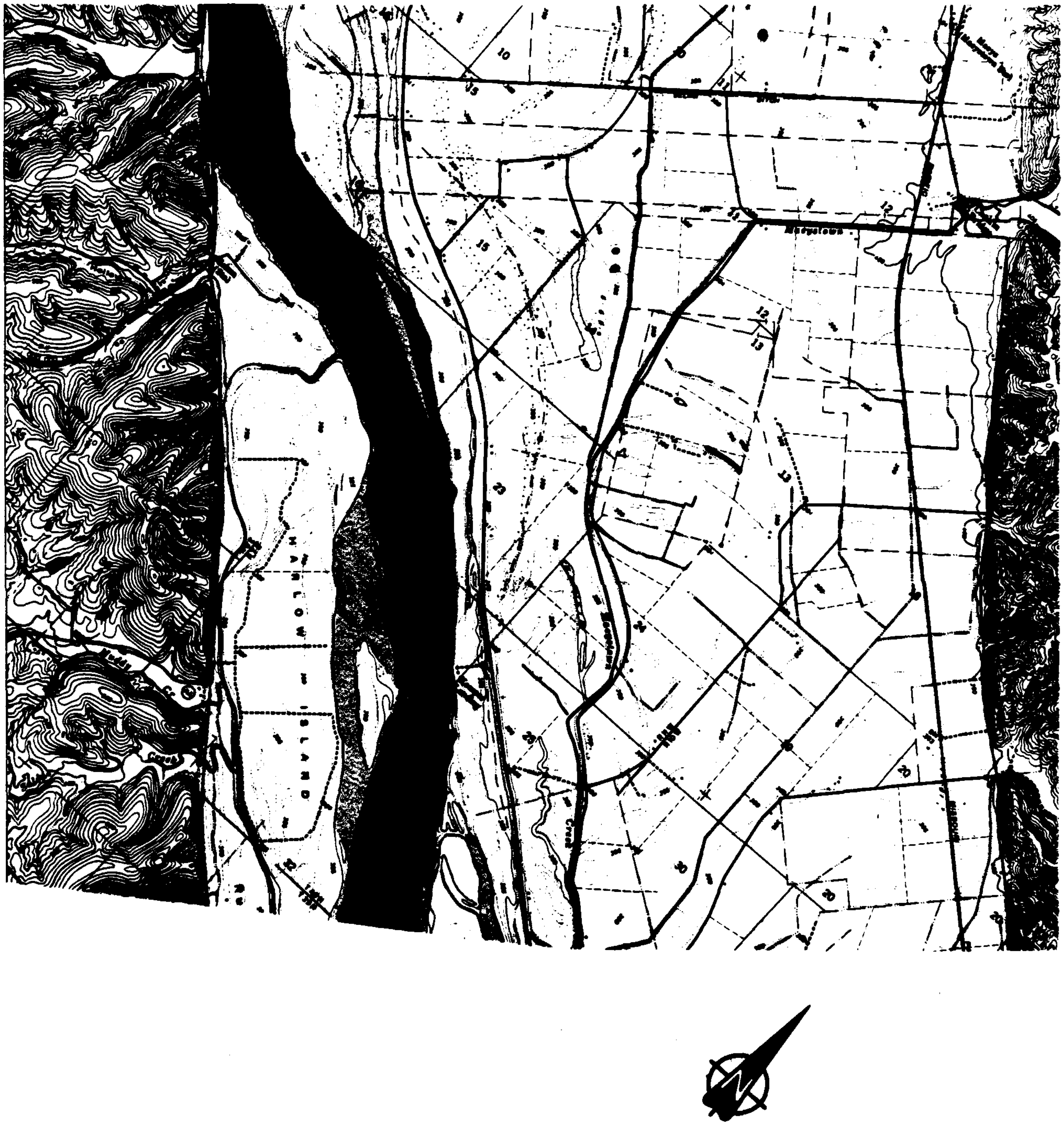

Figure 5-24
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 141-146
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

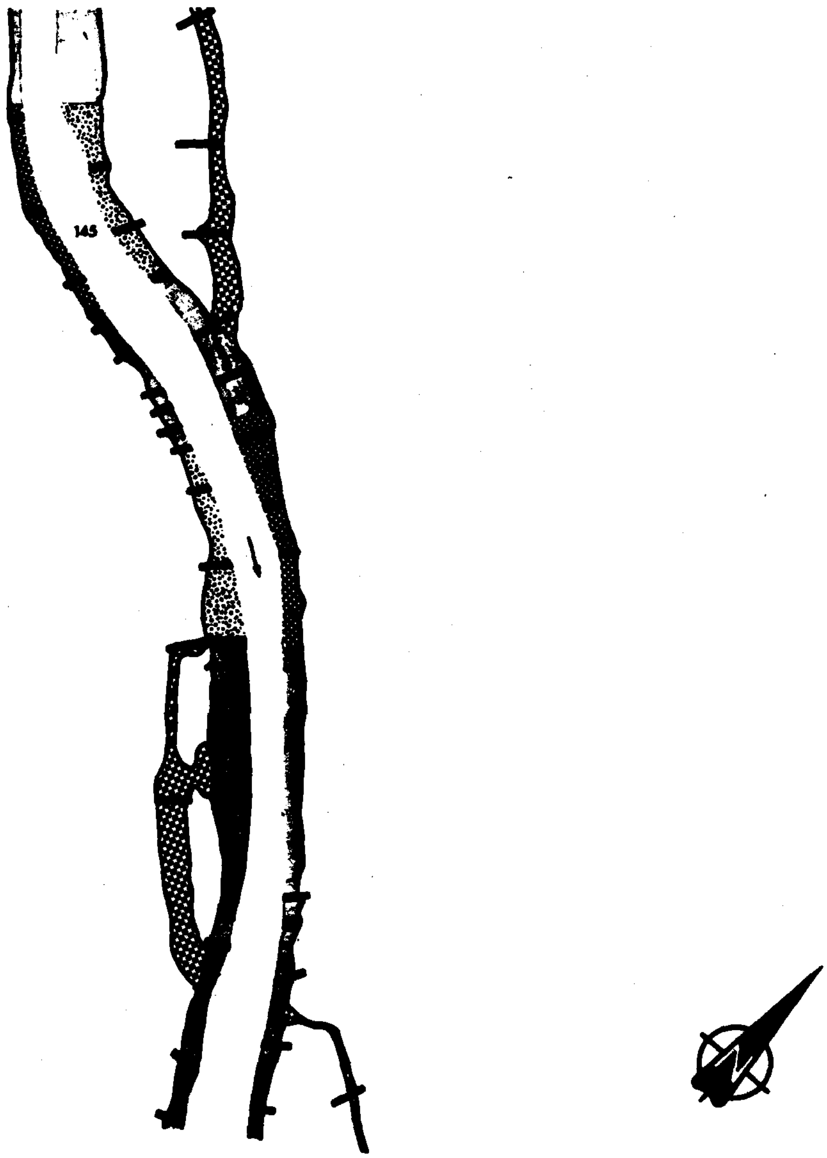

Figure 5-24
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 141-146
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

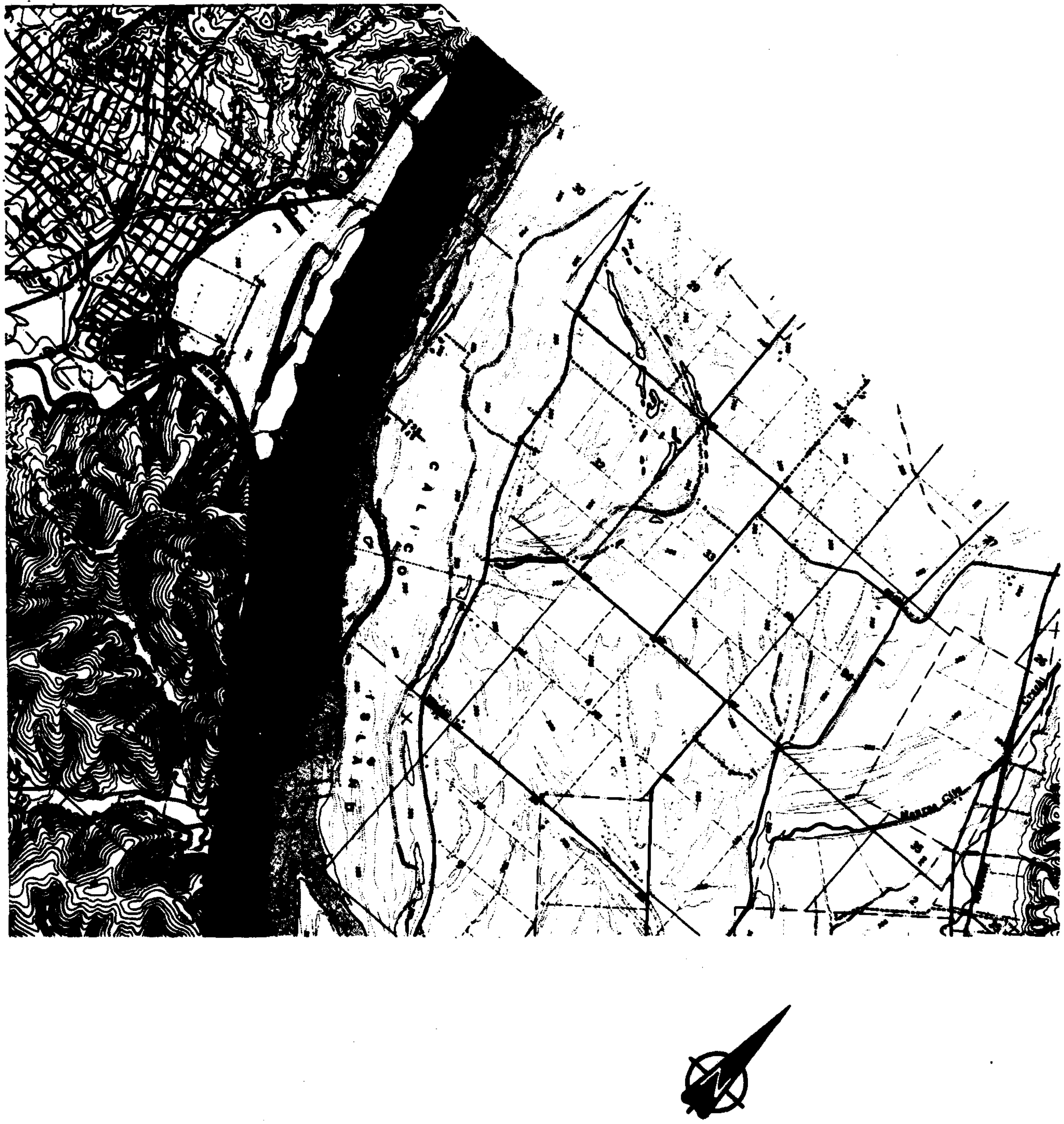

Figure 5-25
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 146-150.7
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

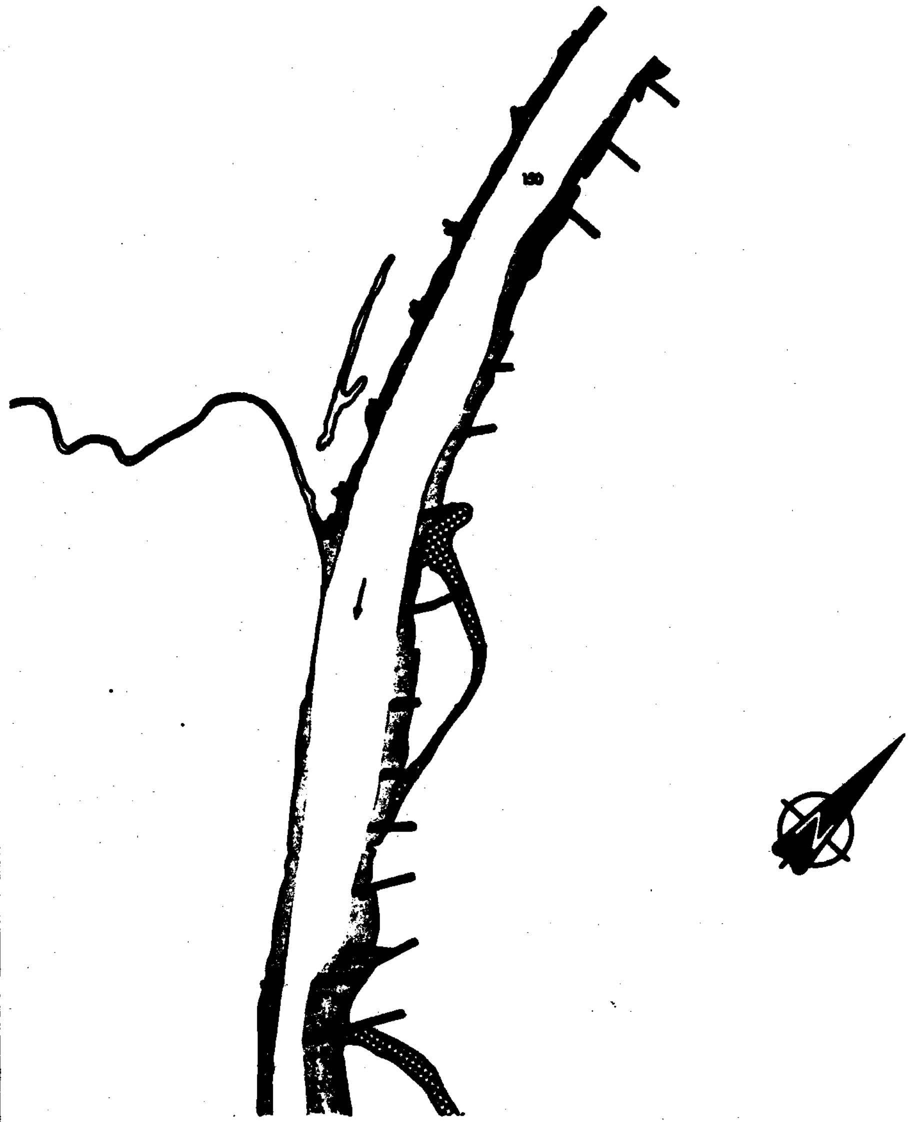

Figure 5-25
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 146-150.7
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-26
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 150.7-157
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

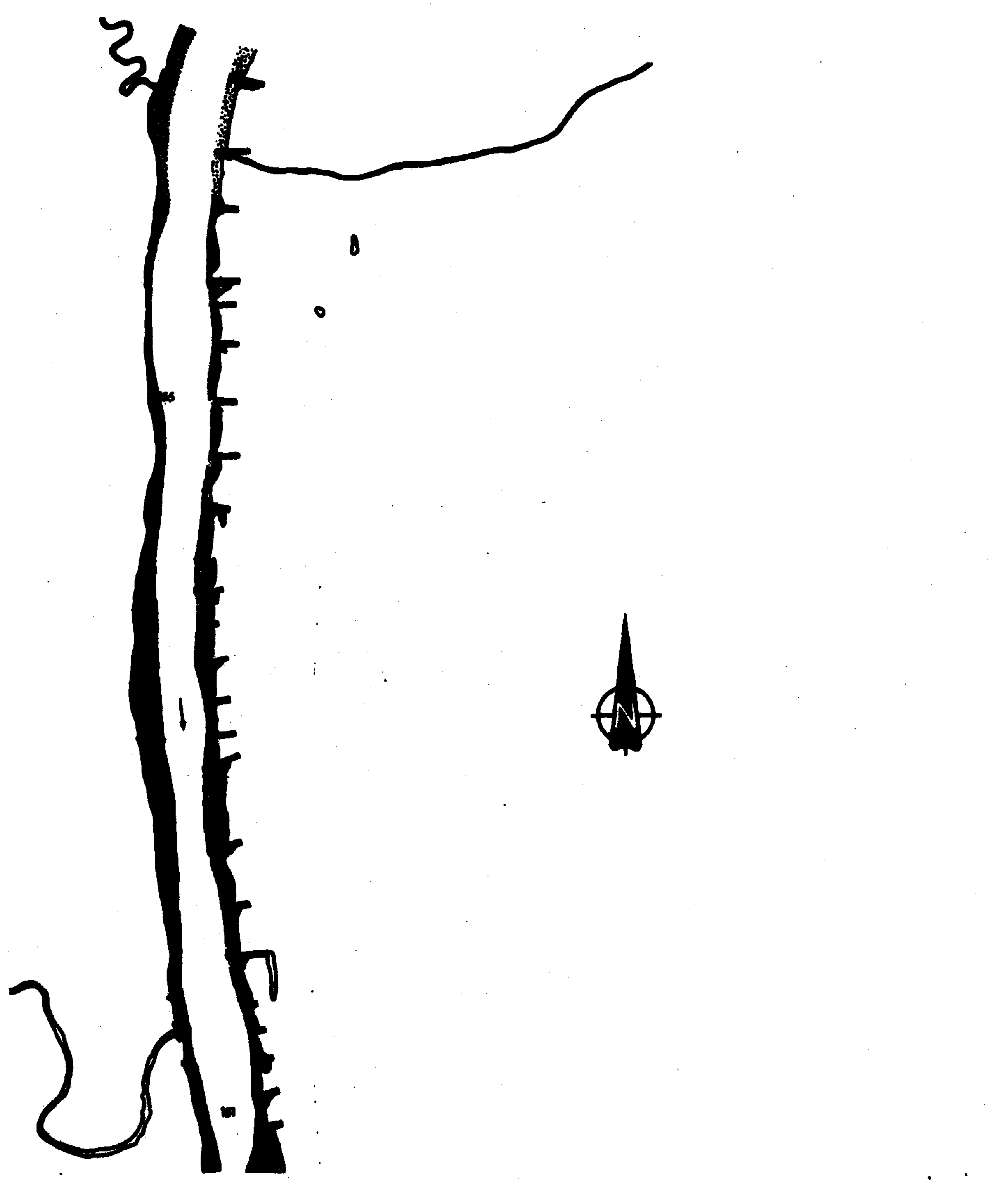

Figure 5-26
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 150.7-157
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-27
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 157-163
SOURCES: U.S. GEOLOGICAL SURVEY, 1975 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-27
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 157-163
SOURCE: [illegible] INC., [illegible]

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

Figure 5-28
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 163-169.8
SOURCES: U.S. GEOLOGICAL SURVEY, 1975/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

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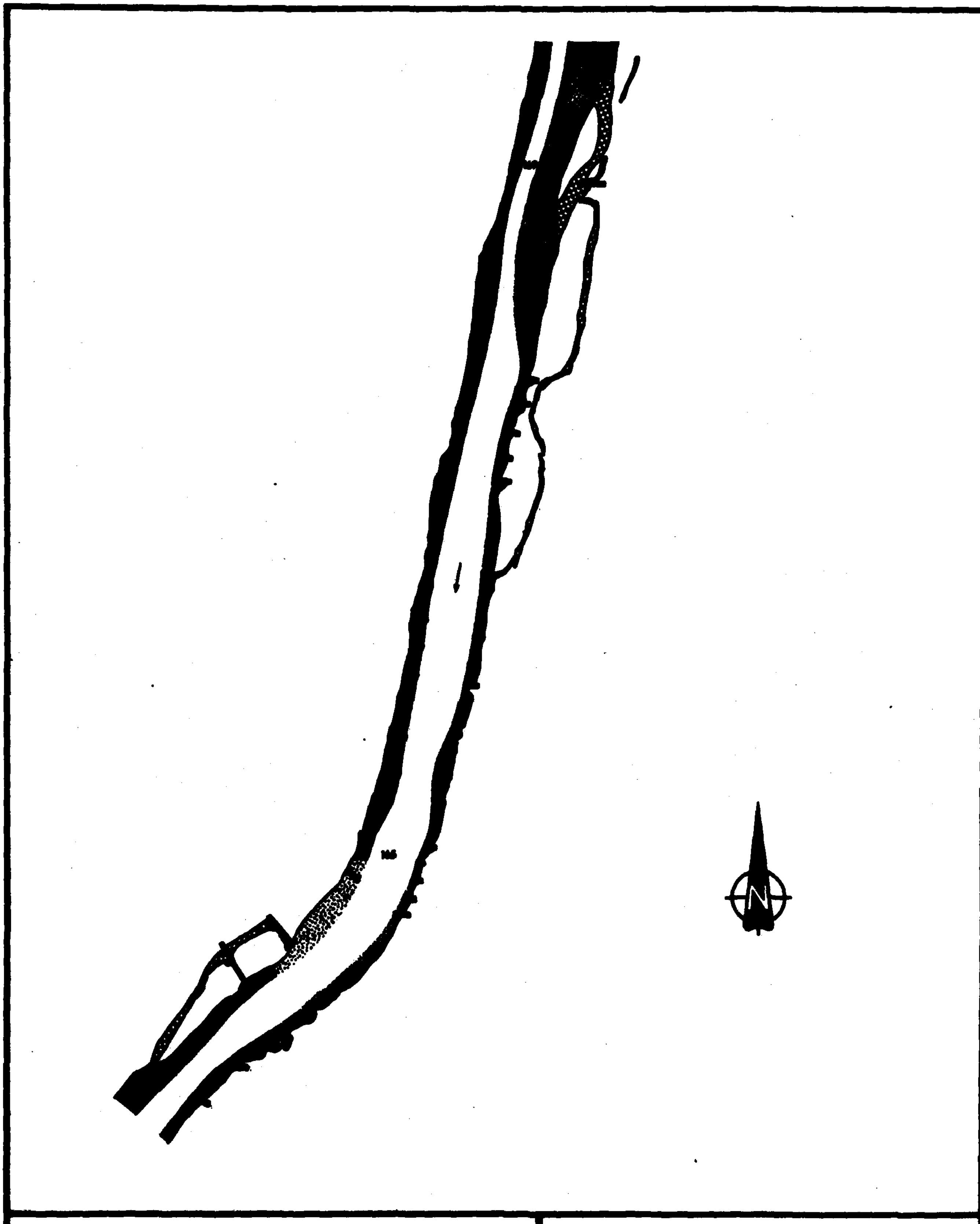

Figure 5-28
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 163-169.8
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

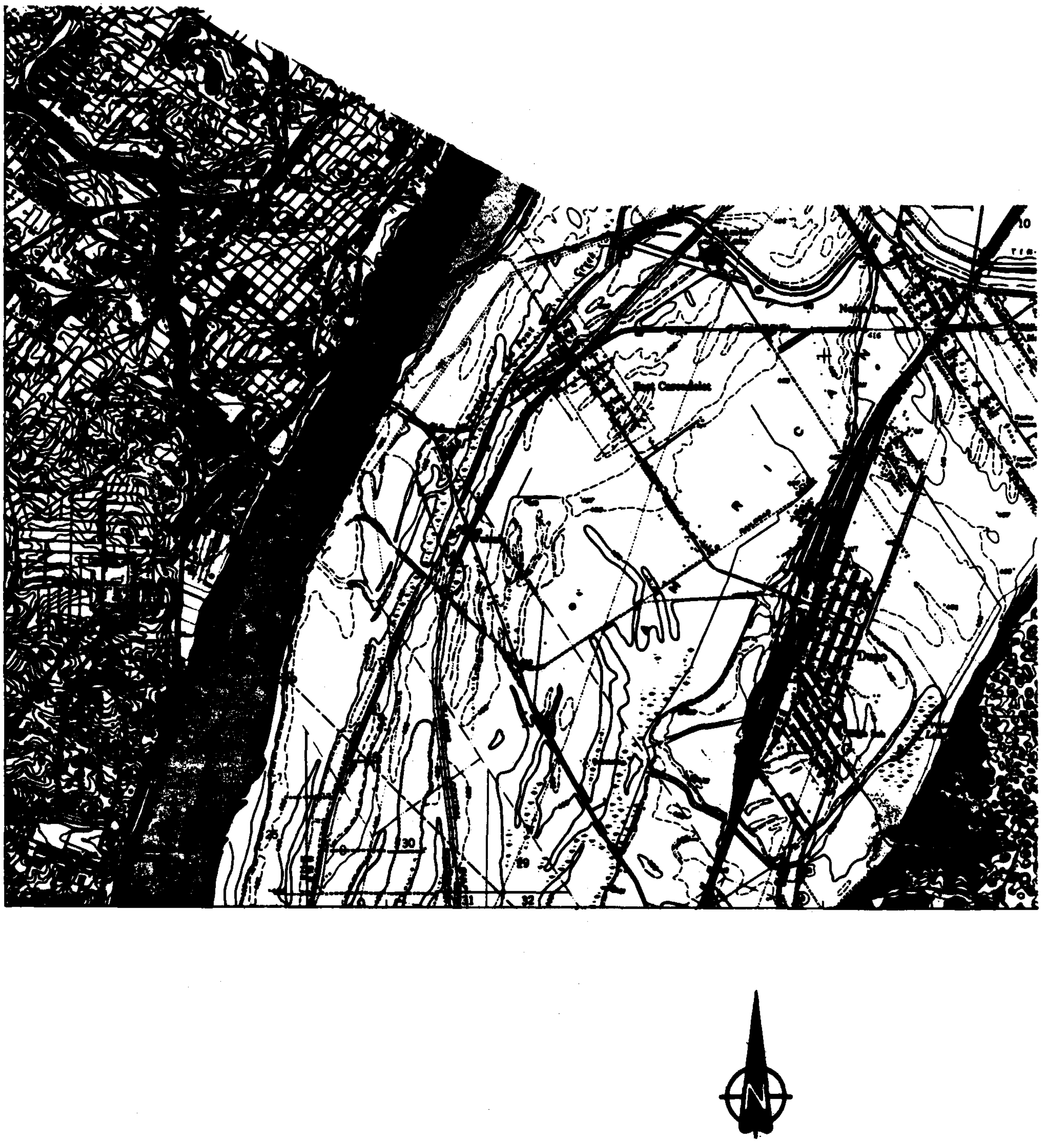

Figure 5-29
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 169.8-174
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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Figure 5-29
AQUATIC HABITATS.
MISSISSIPPI RIVER MILES 169.8-174
SOURCE: ESE INC., 1982

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Figure 5-30
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 174-179.8
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

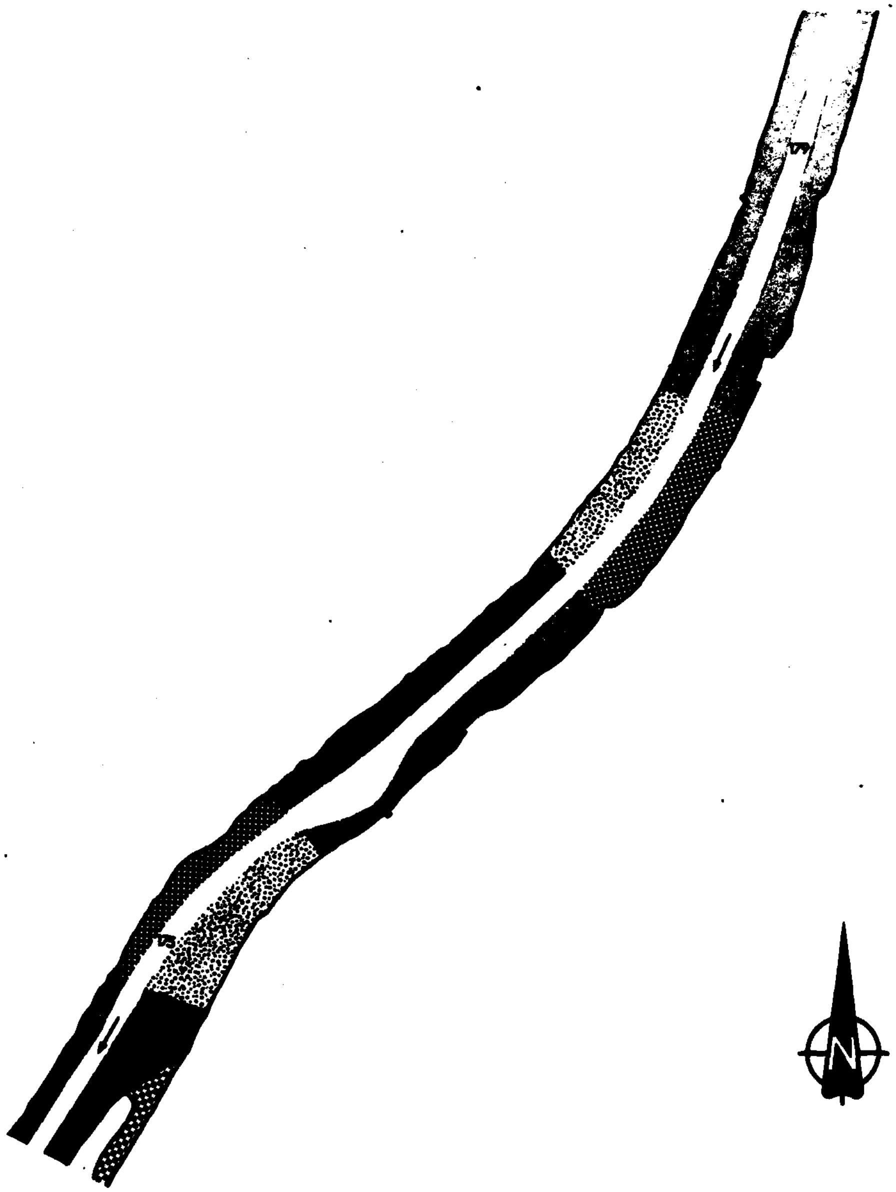

Figure 5-30
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 174-179.8
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

Figure 5-31
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 179.8-184
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

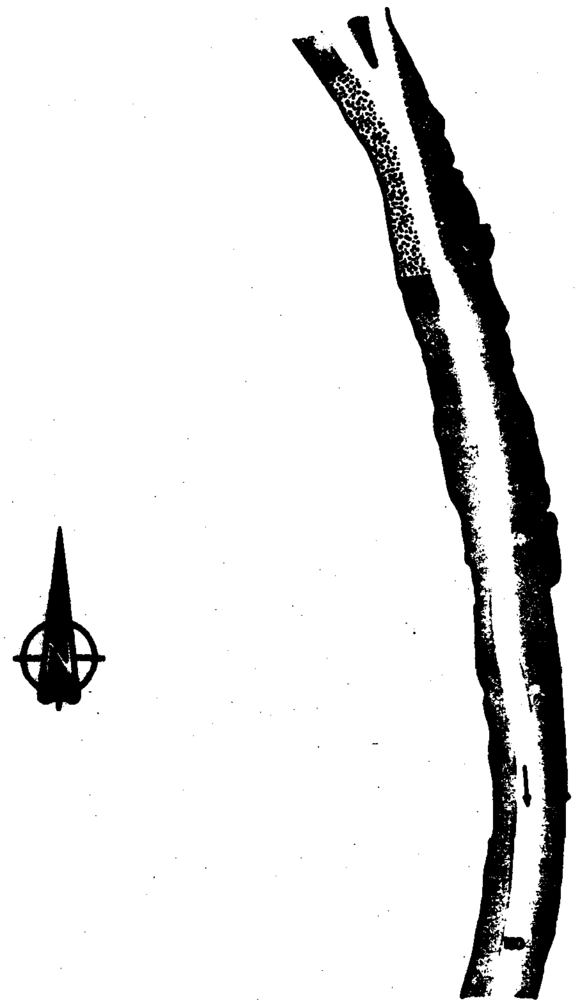

Figure 5-31
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 179.8-184
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-32
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 184-189.8
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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Figure 5-32 AQUATIC HABITATS, MISSISSIPPI RIVER MILES 184-189.8 SOURCE: ESE INC., 1982	GREAT III ECOLOGICAL CHARACTERIZATION St. Louis District Army Corps of Engineers

Figure 5-33
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 189.8-196
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

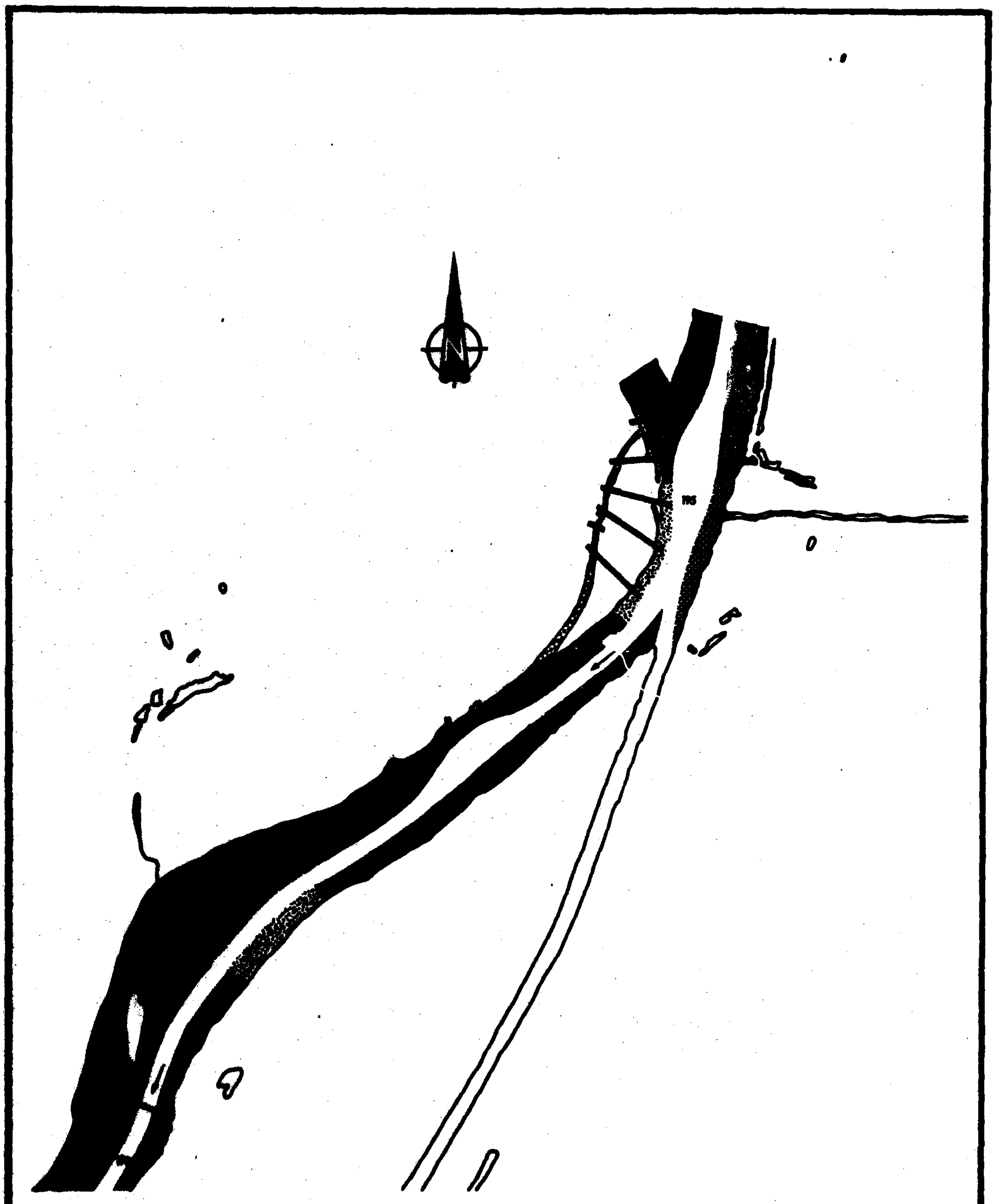

Figure 5-33
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 189.8-196
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GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

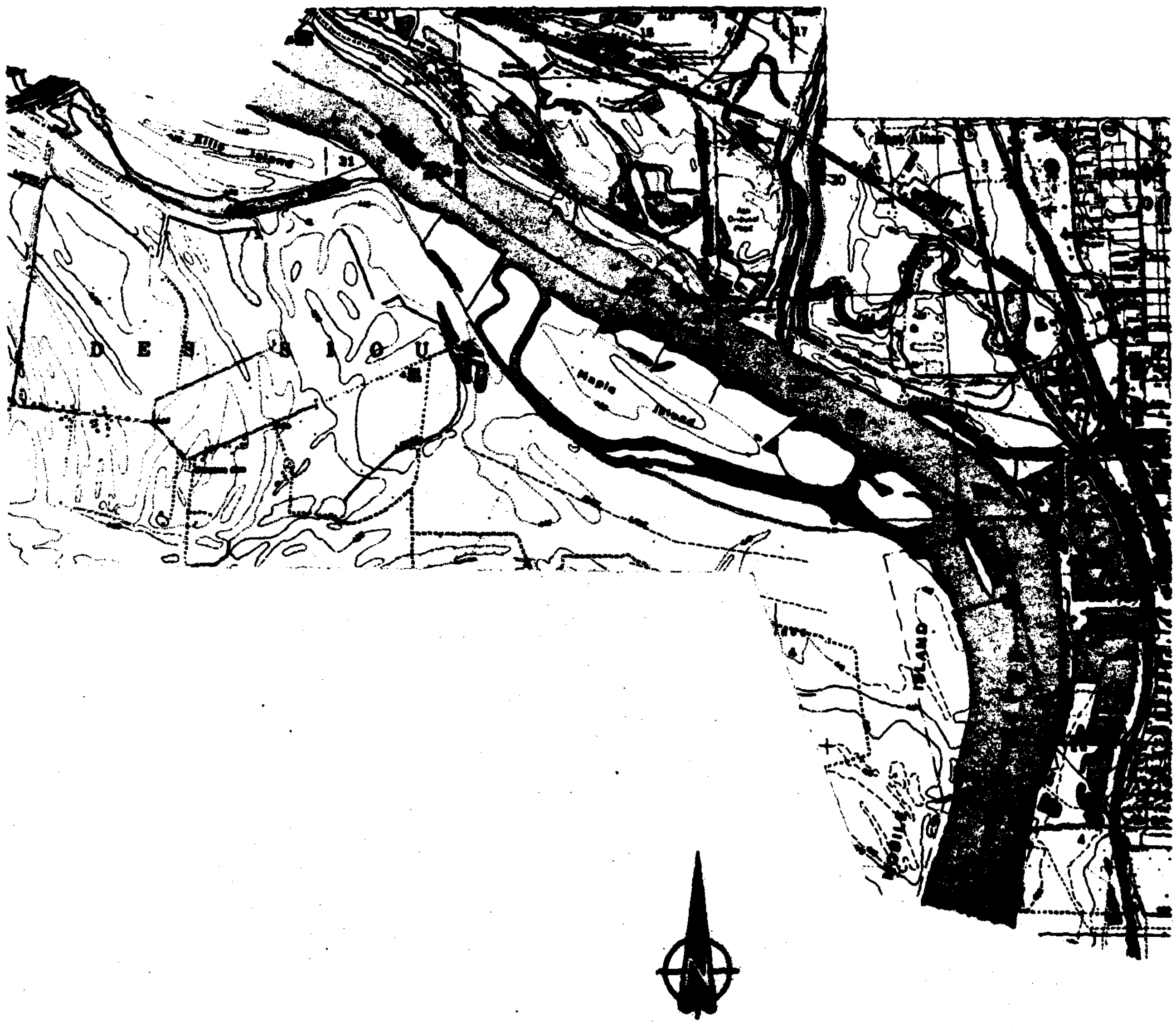

Figure 5-34
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 196-202
SOURCES: U.S. GEOLOGICAL SURVEY, 1975 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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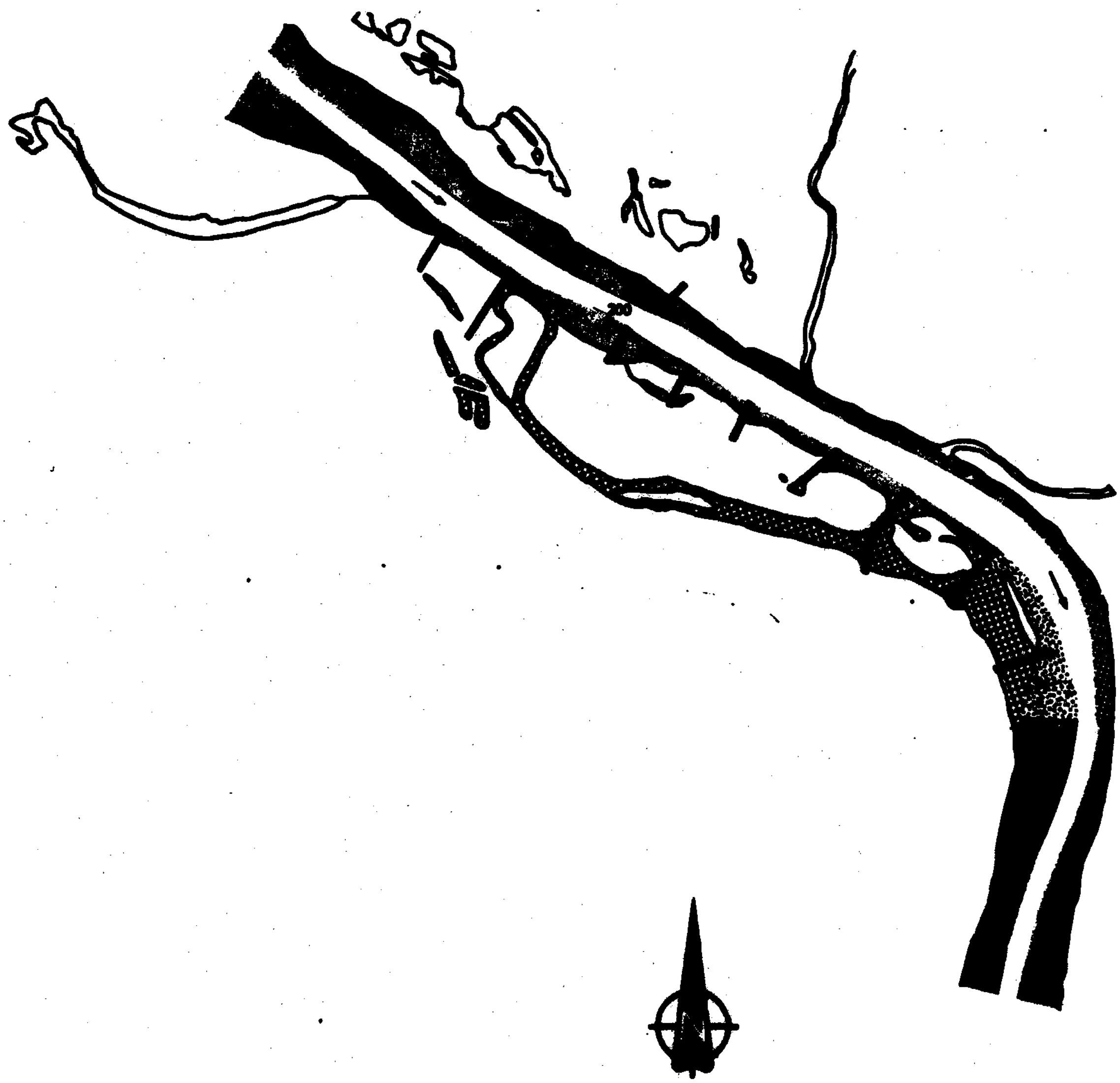

Figure 5-34
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 196-202
SOURCE: ESE INC., [illegible]

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-35
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 202-207.5
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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Figure 5-35
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 202-207.5
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

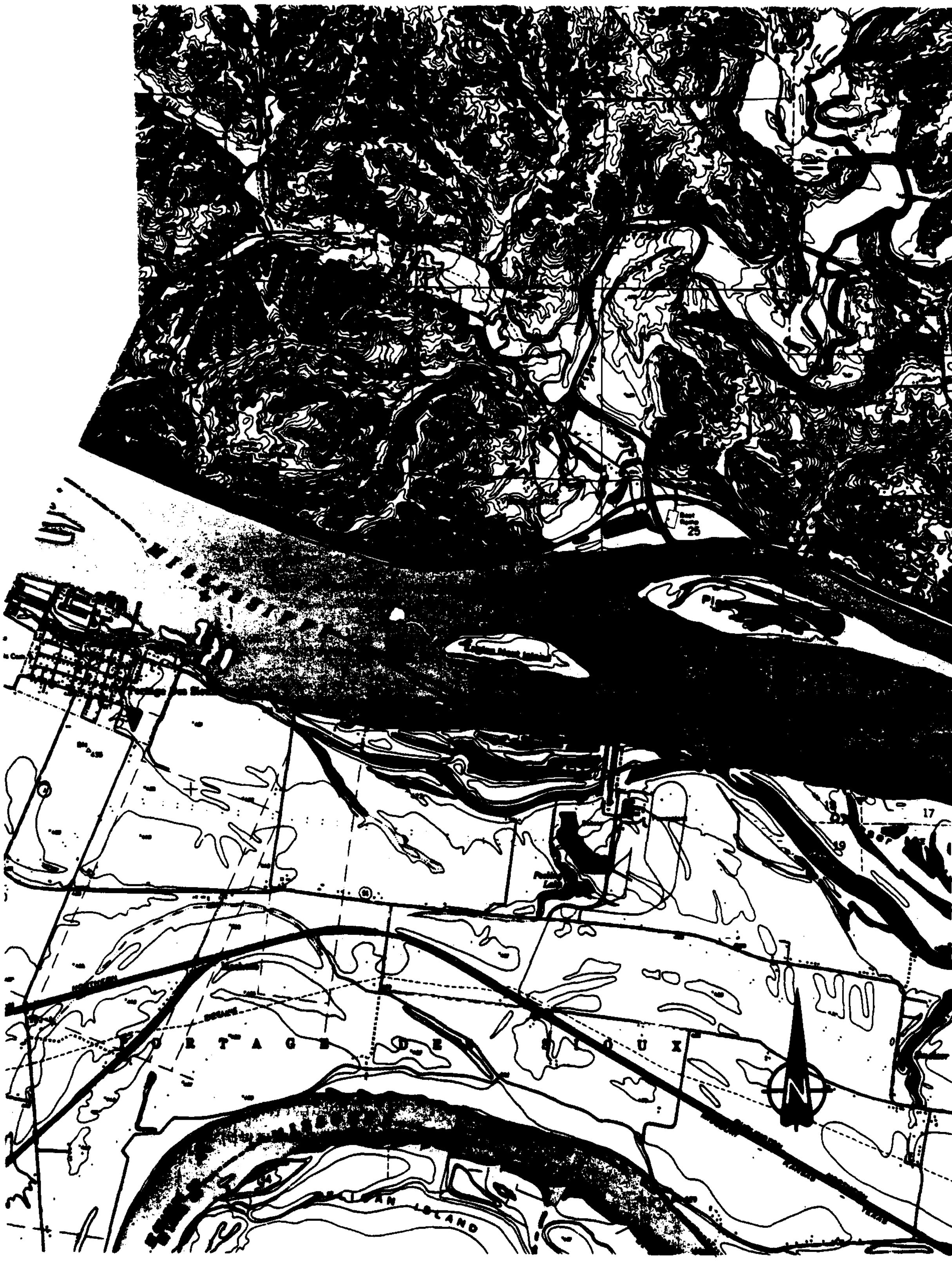

Figure 5-36
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 207.5-213
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

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Figure 5-36
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 207.5-213
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

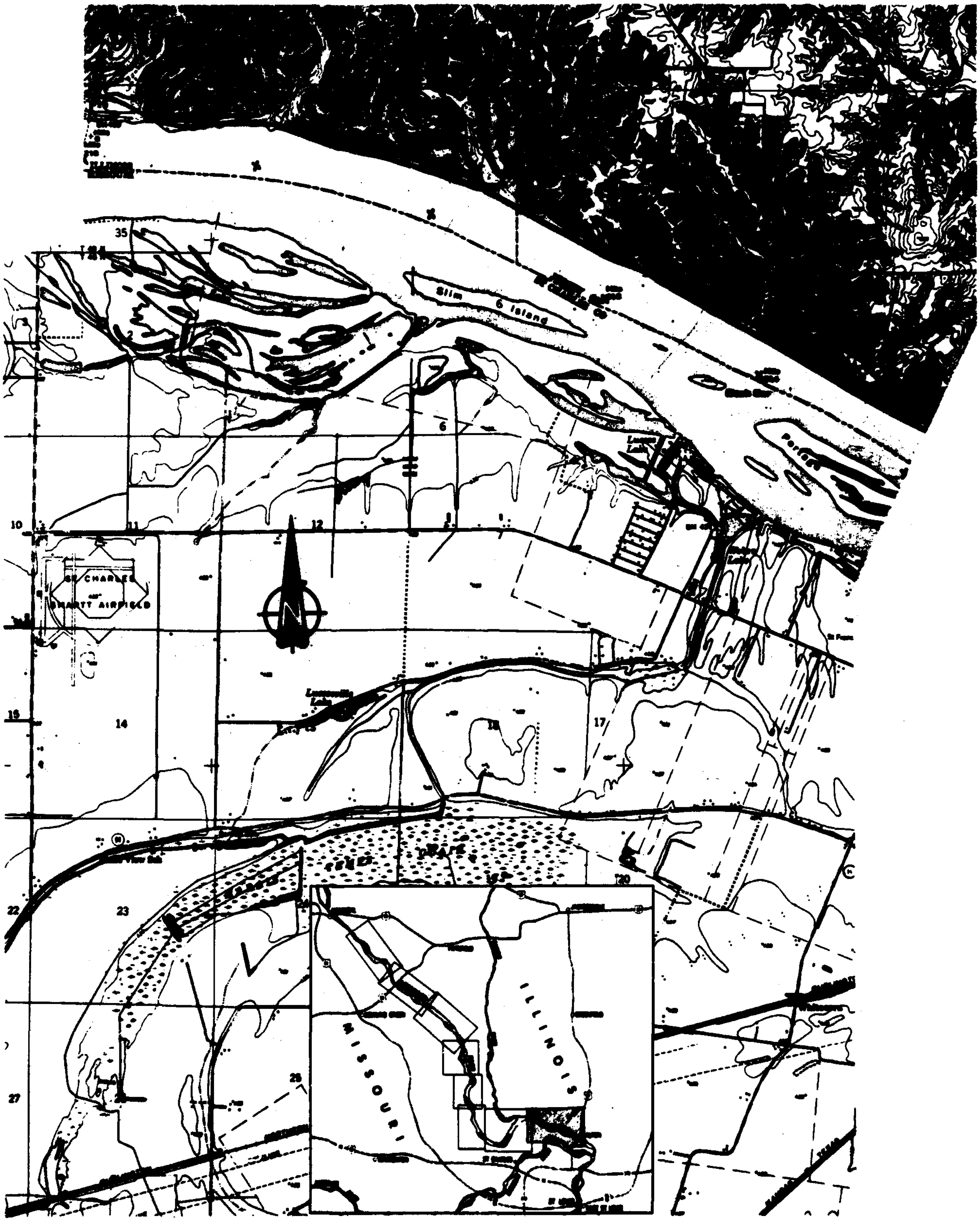

Figure 5-37
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 213-218
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-37
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 213-218
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

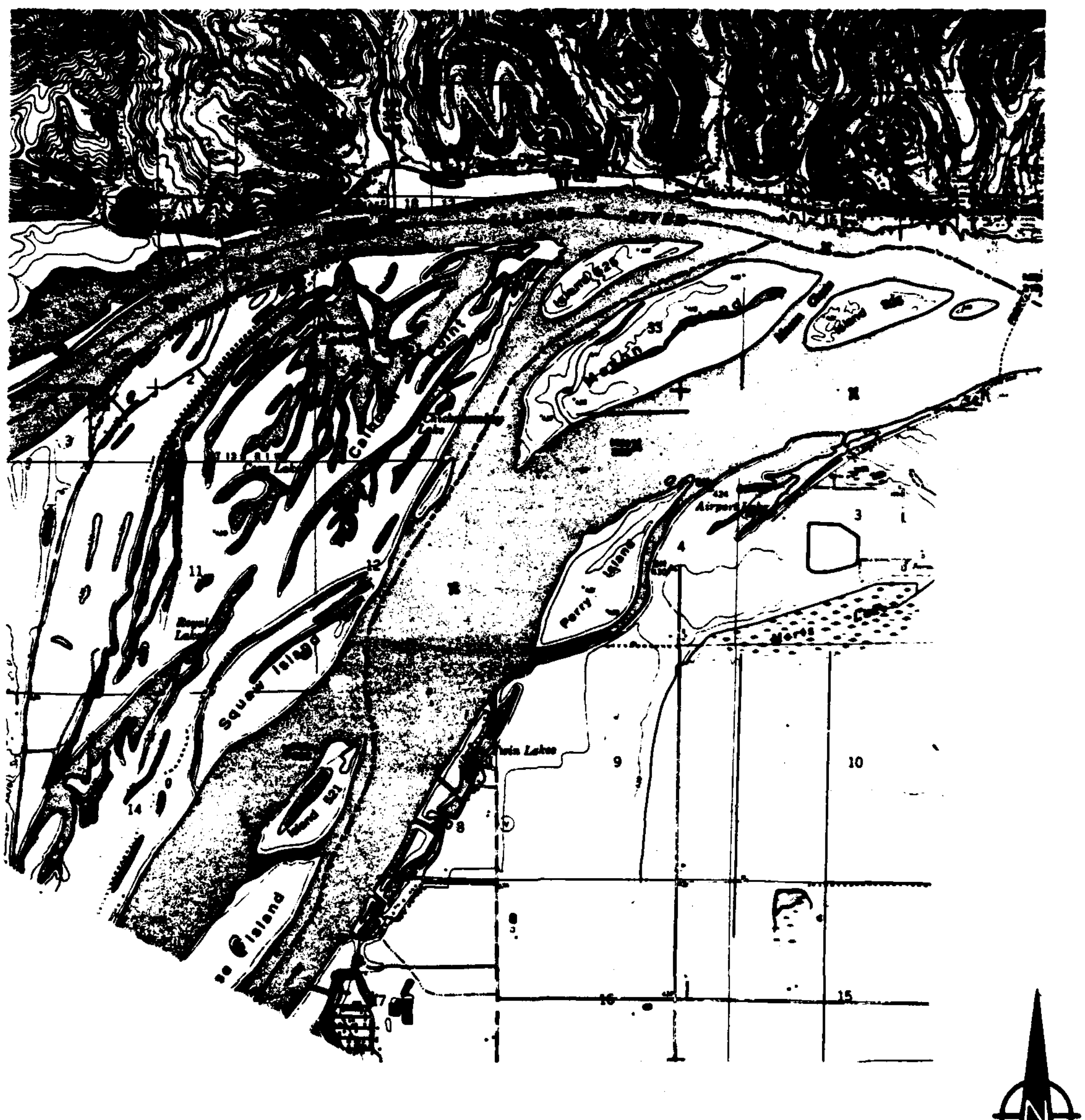

Figure 5-38
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 218-223
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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Figure 5-38 **AQUATIC HABITATS,** **MISSISSIPPI RIVER MILES 218-223** **SOURCE: ESE INC., 1982**	**GREAT III ECOLOGICAL CHARACTERIZATION** **St. Louis District Army Corps of Engineers**

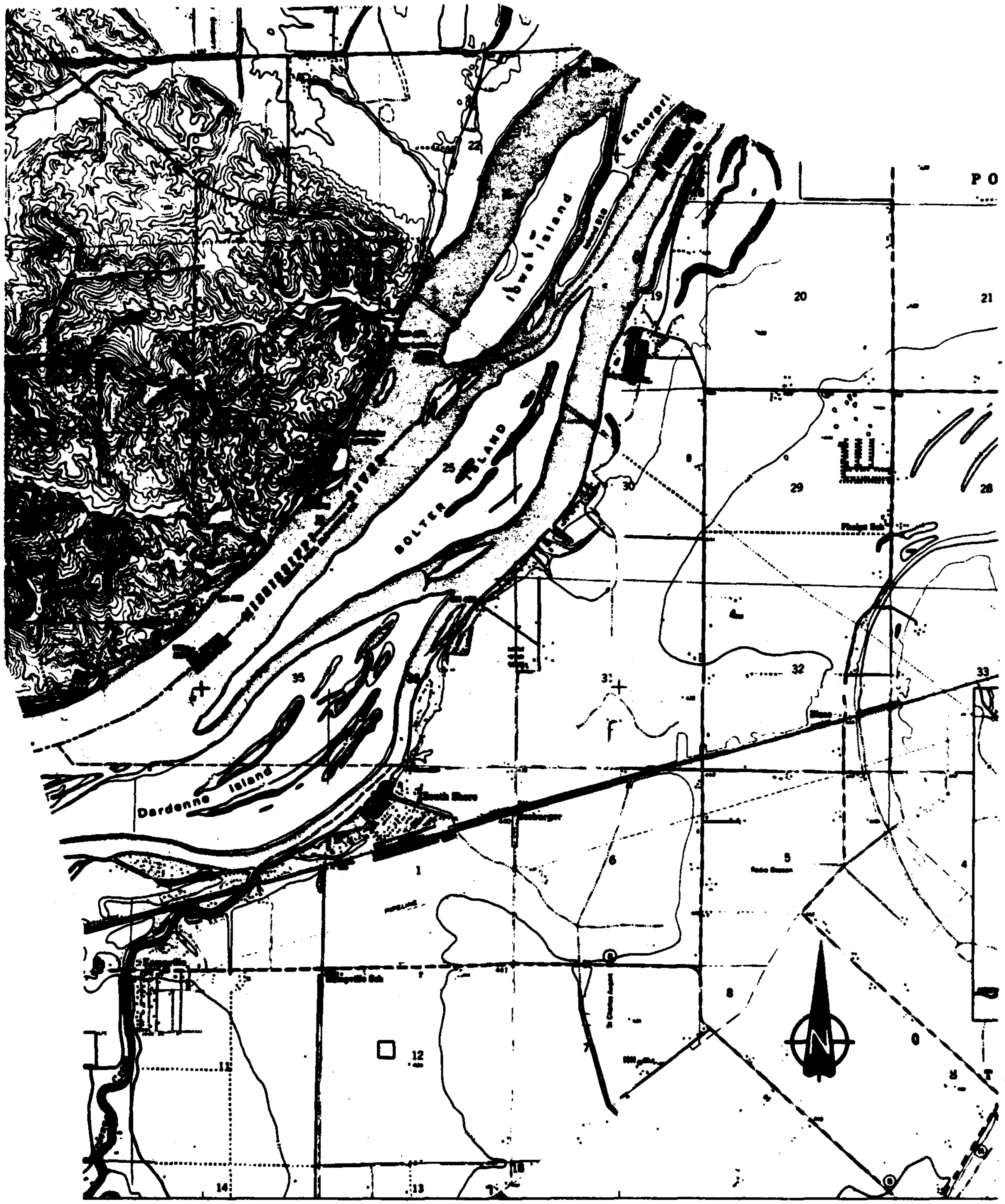

Figure 5-39
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 223-228
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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Figure 5-39 AQUATIC HABITATS, MISSISSIPPI RIVER MILES 223-228 SOURCE: ESE INC., 1982	GREAT III ECOLOGICAL CHARACTERIZATION St. Louis District Army Corps of Engineers

Figure 5-40
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 228-232.2
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-40 AQUATIC HABITATS, MISSISSIPPI RIVER MILES 228-232.2 SOURCE: ESE INC., 1982	GREAT III ECOLOGICAL CHARACTERIZATION St. Louis District Army Corps of Engineers

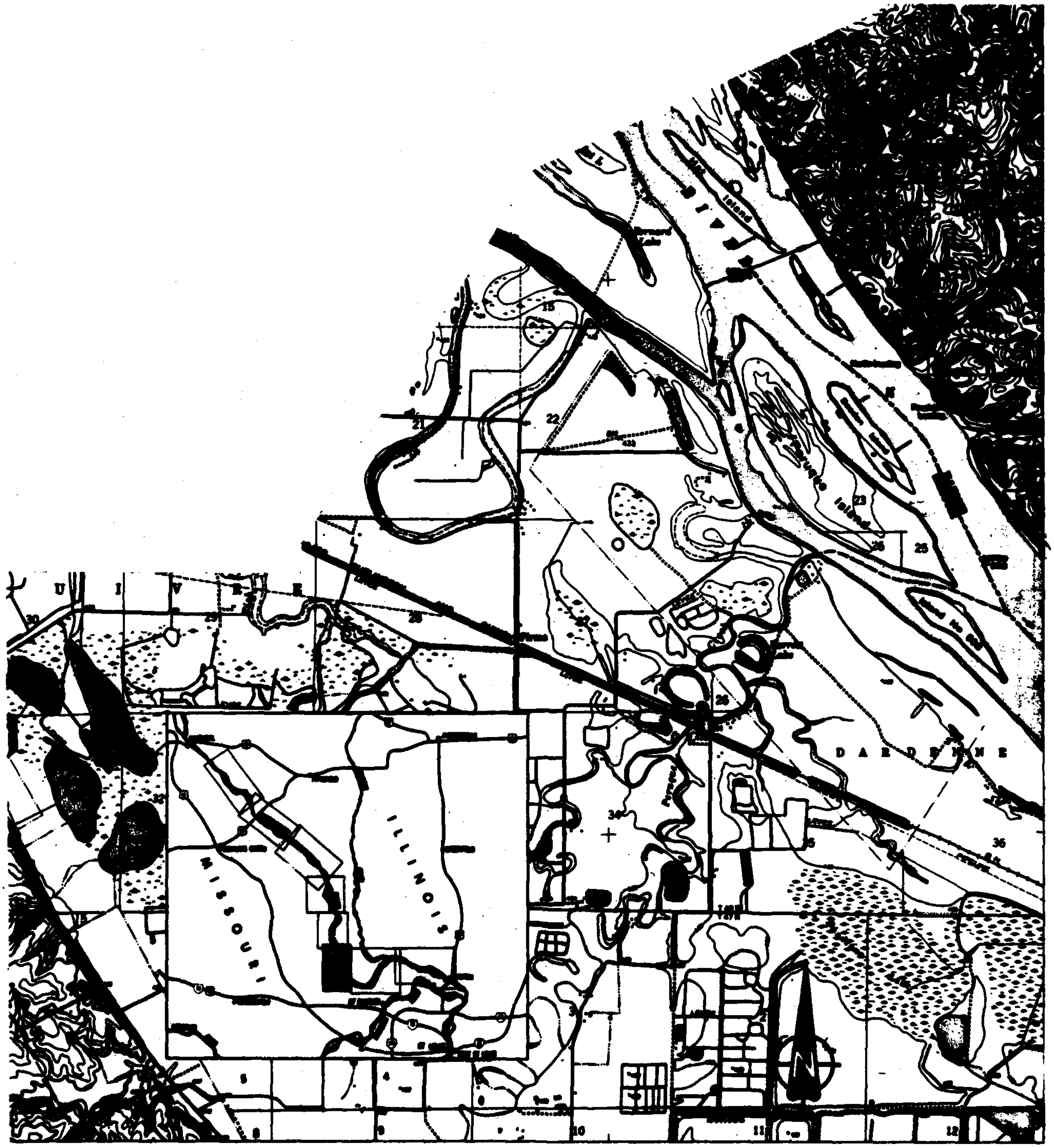

Figure 5-41
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 232.2-236
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

Figure 5-41
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 232.2-236
SOURCE: [illegible]

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

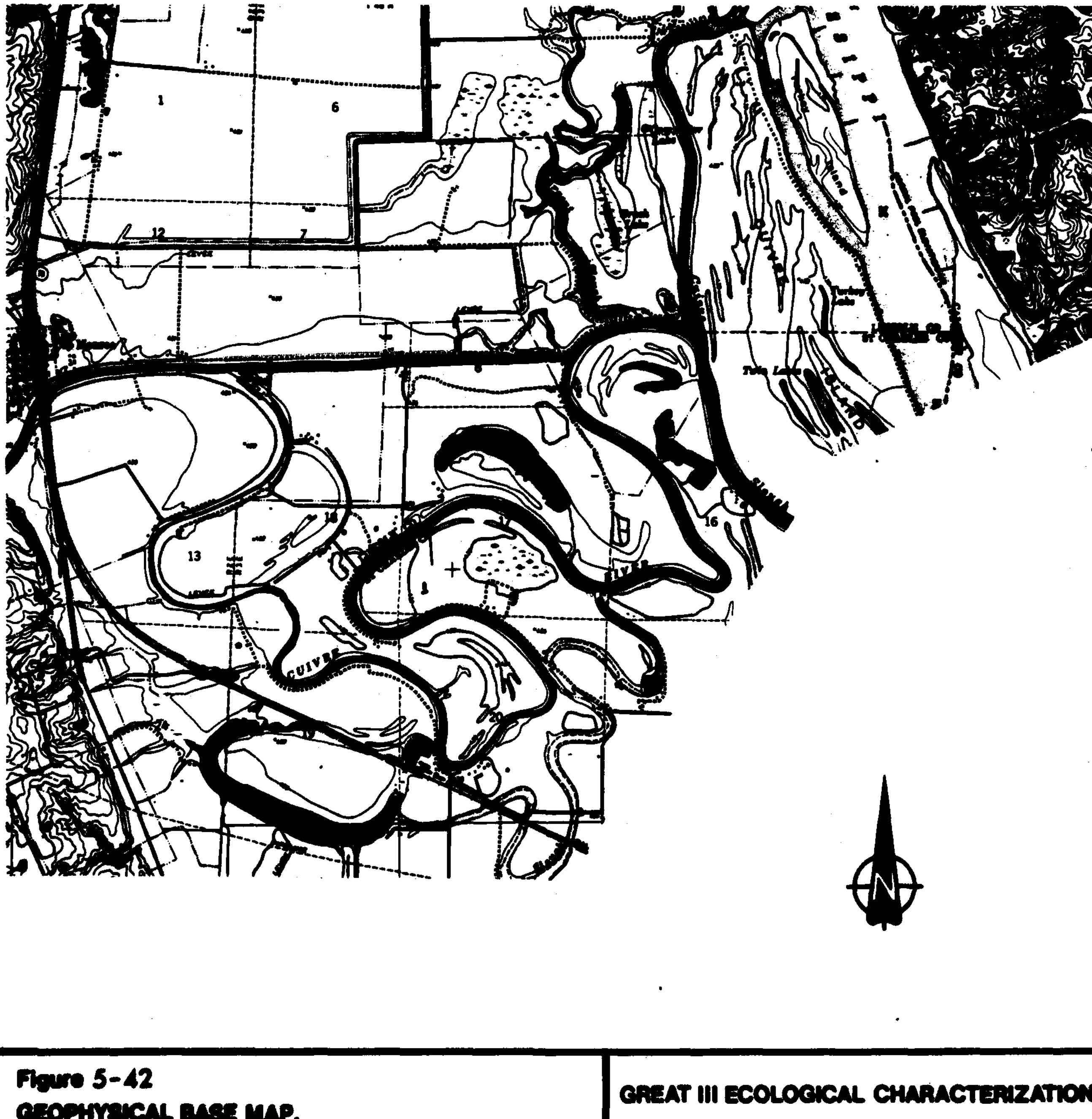

Figure 5-42
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 236-238
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

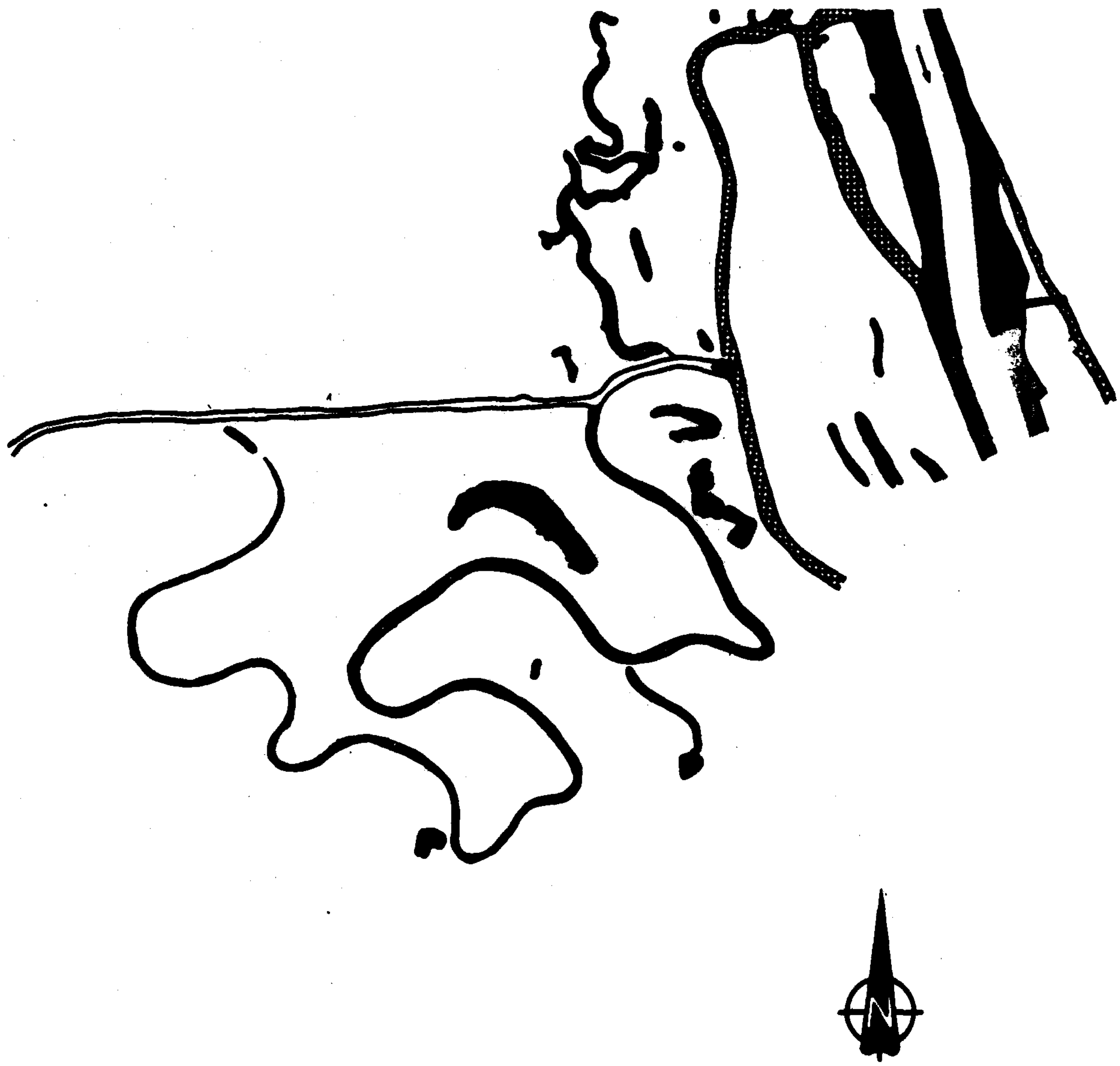

Figure 5-42
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 236-238
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

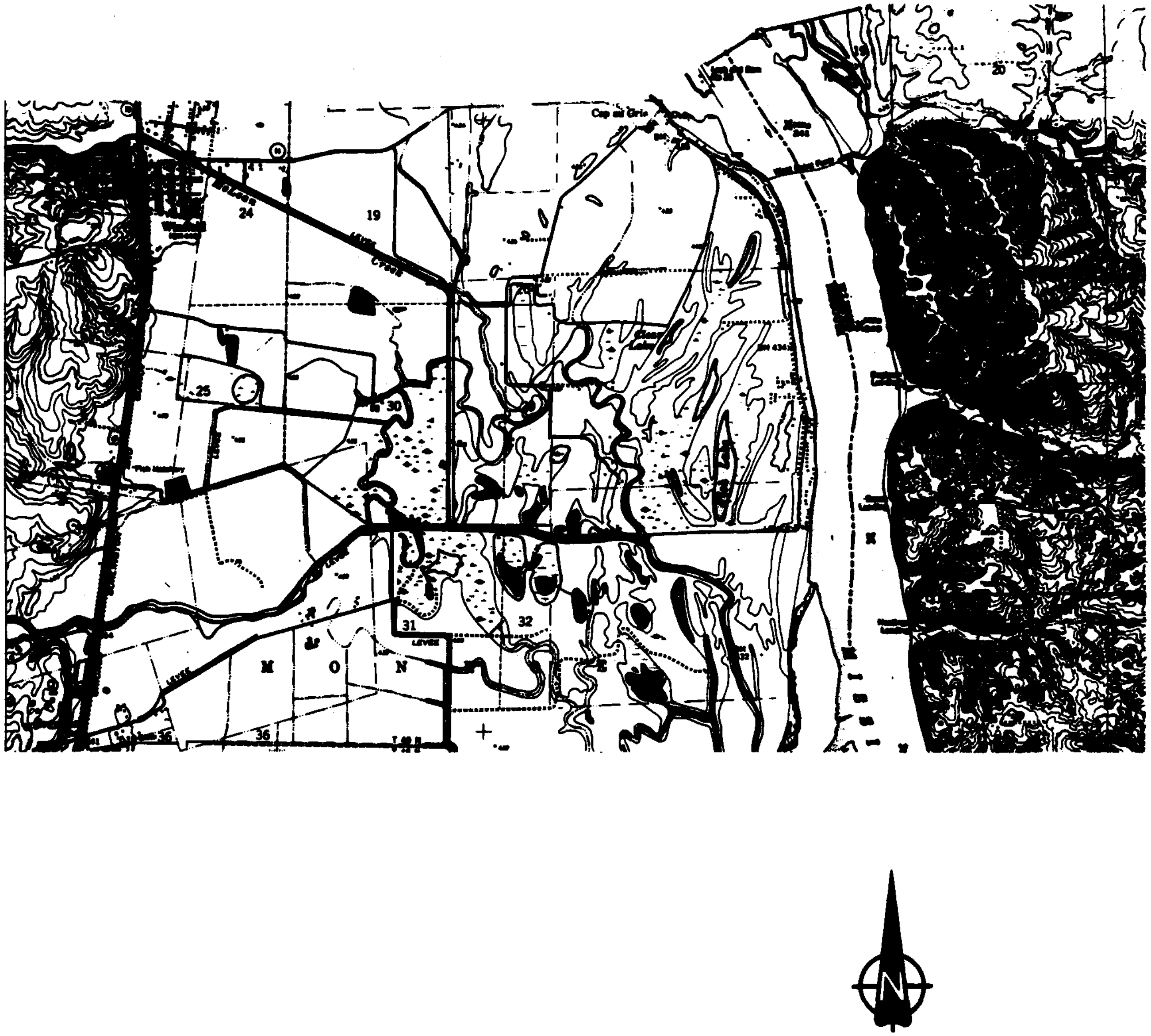

Figure 5-43
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 238-241.5
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-43
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 238-241.5
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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Figure 5-44
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 241.5-247
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

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Figure 5-44
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 241.5-247
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

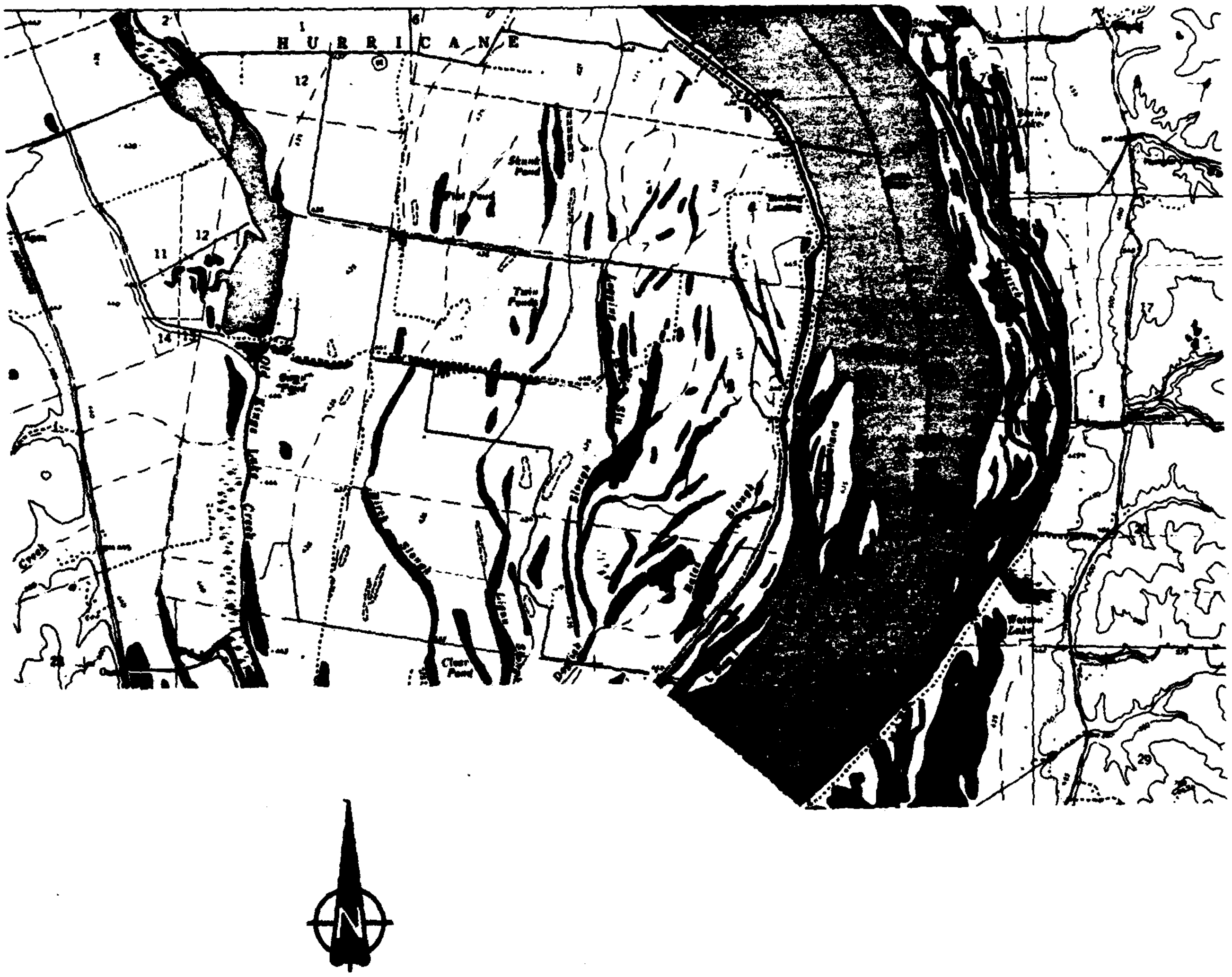

Figure 5-45
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 247-250.9
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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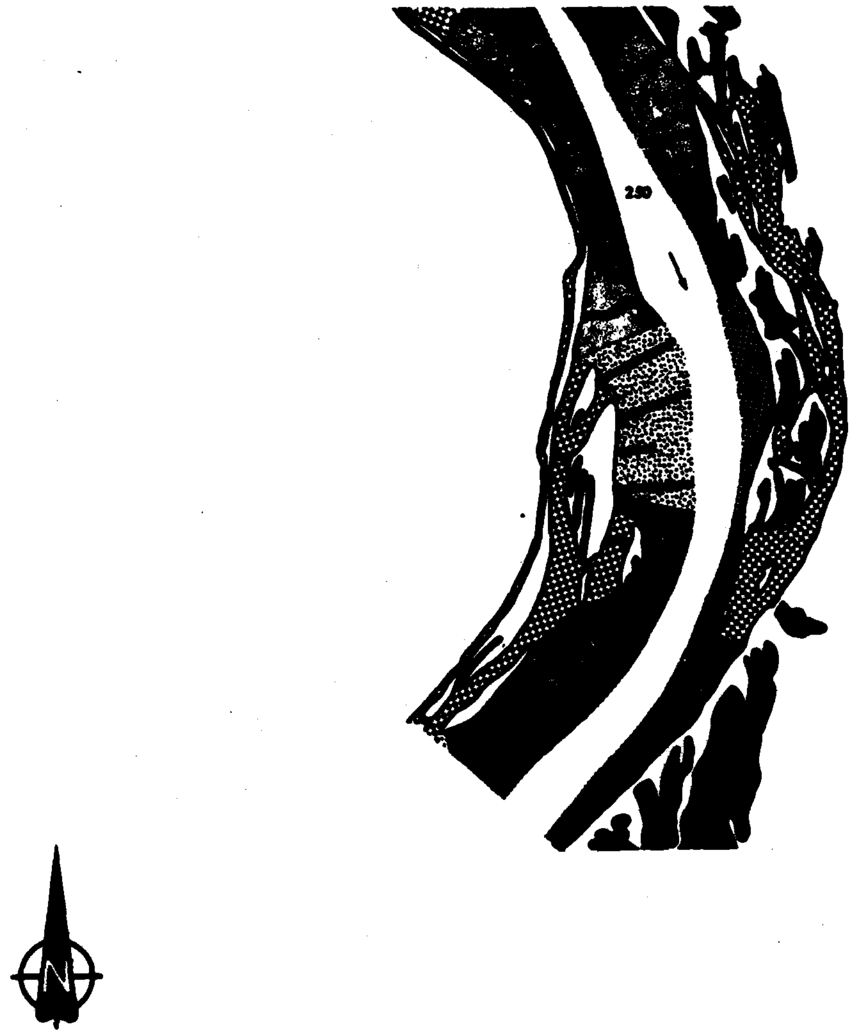

Figure 5-45
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 247-250.9
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

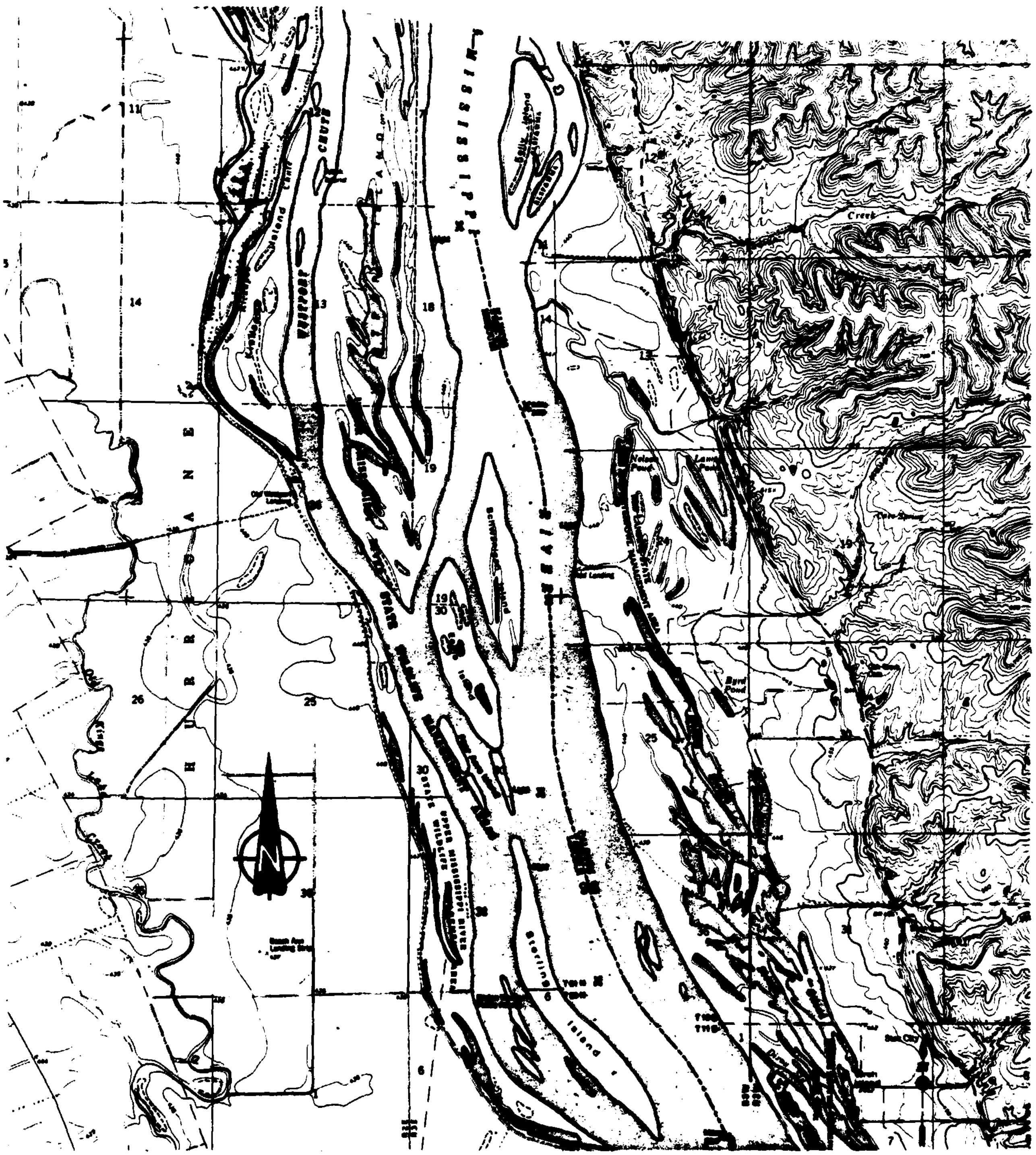

Figure 5-46
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 250.9-257
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

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Figure 5-46
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 250.9-257
SOURCE: ESE INC., 1982

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Figure 5-47
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 257-259.9
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

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Figure 5-47
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 257-259.9
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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Figure 5-48
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 259.9-267
SOURCES: U.S. GEOLOGICAL SURVEY, 1979 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

Figure 5-48
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 259.9-267
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

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Figure 5-49
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 267-273.4
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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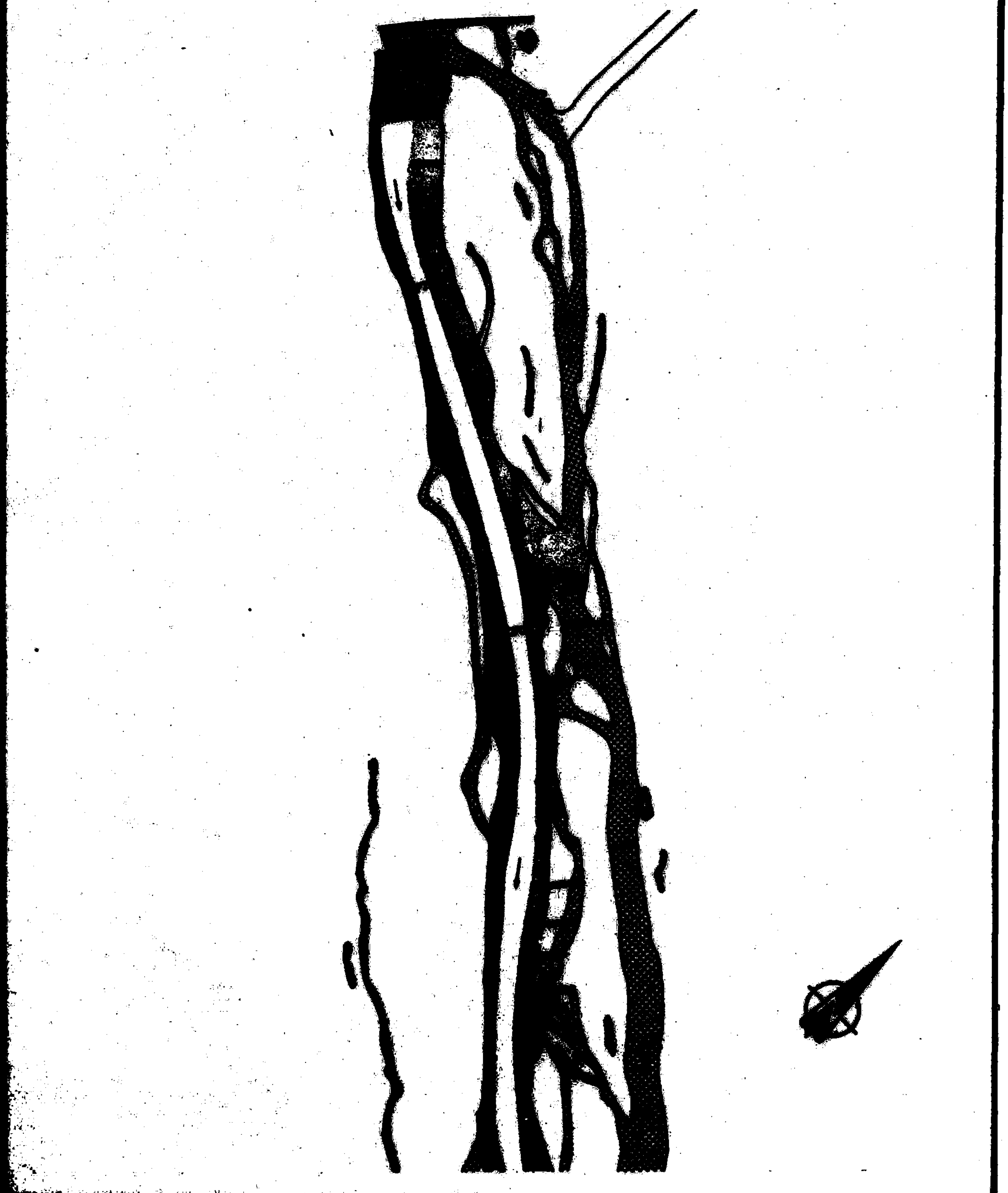

[illegible]
[illegible]
[illegible] MILES 267–273.4
[illegible]

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

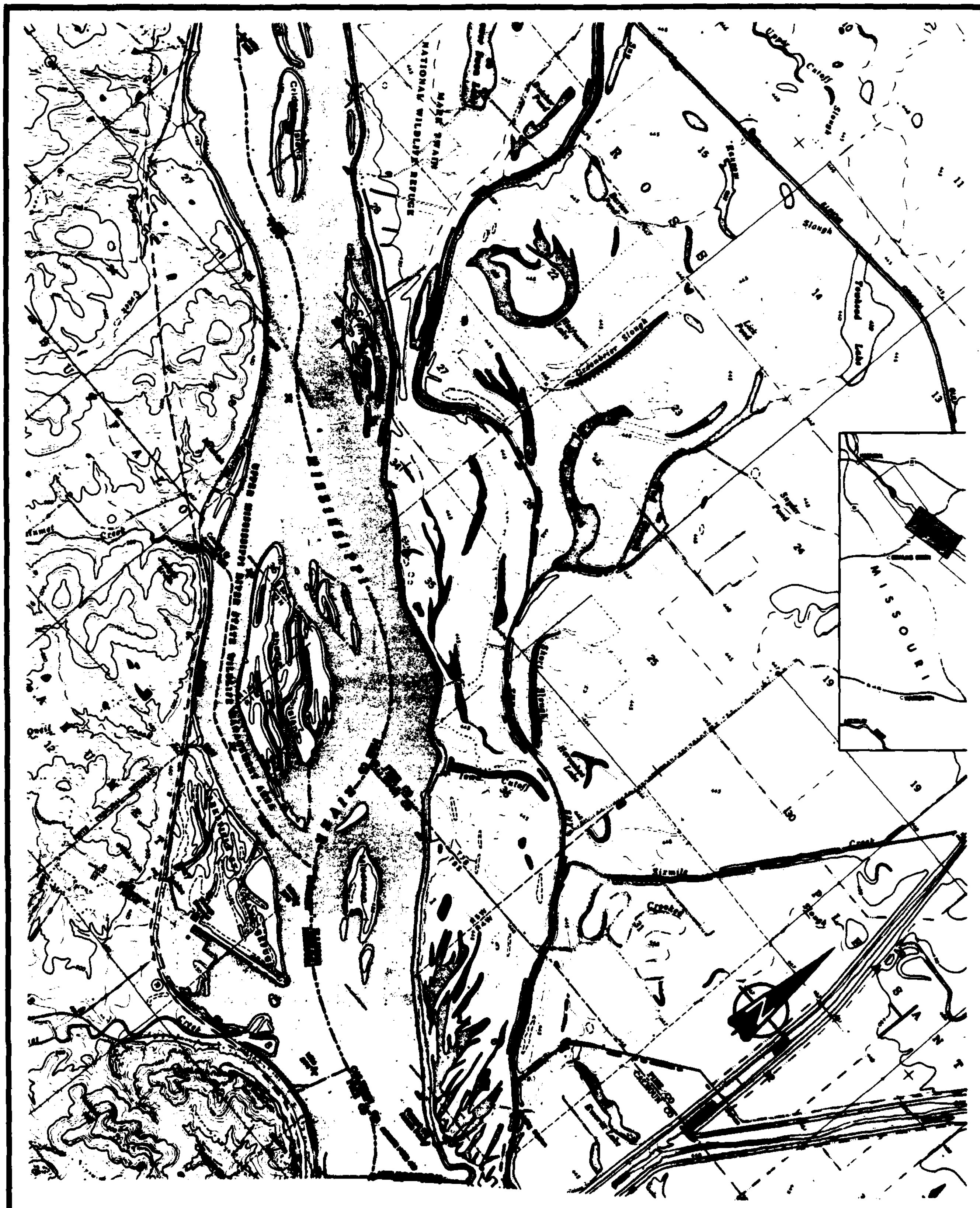

Figure 5-50
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 273.4-280.1
SOURCES: U.S. GEOLOGICAL SURVEY, 1978/ ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION

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Figure 5-50
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 273.4 - 280.1
SOURCE: ESE INC., 1982

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Figure 5-51
GEOPHYSICAL BASE MAP,
MISSISSIPPI RIVER MILES 280.1-287.4
SOURCES: U.S. GEOLOGICAL SURVEY, 1978 / ESE, INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
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Figure 5-51
AQUATIC HABITATS,
MISSISSIPPI RIVER MILES 280.1-287.4
SOURCE: ESE INC., 1982

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers

AD-A120 809 GREAT III - ECOLOGICAL AND HABITAT CHARACTERIZATION PRIMARY DOCUMENT(U) ENVIRONMENTAL SCIENCE AND ENGINEERING INC ST LOUIS MO B P BOROFKA MAY 82 3/5

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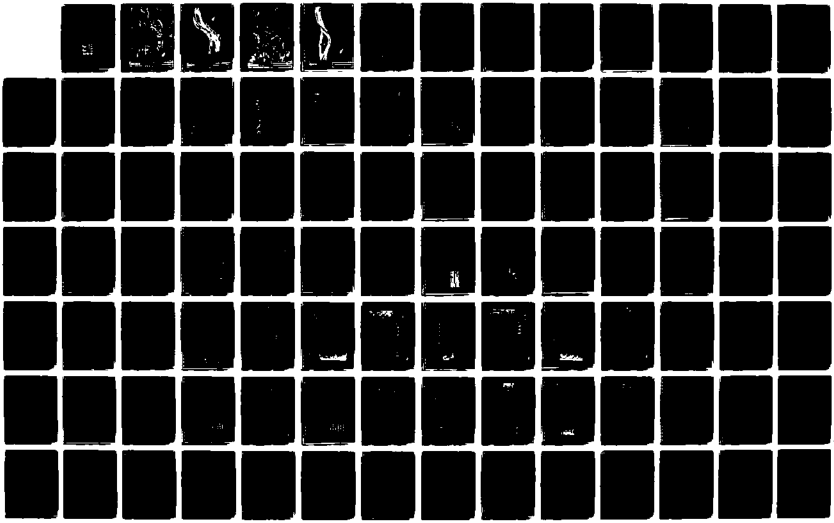

3.5.8 RELATIVE ABUNDANCE OF HABITAT TYPES

The habitats mapped on the open river reach of the study area (River Miles 0 to 202) were:

1. Main Channel,
2. Main Channel Border,
3. Side Channel, and
4. Tributary Mouth.

The main channel border was subdivided into straight reaches, inside bends, and outside bends.

The aquatic habitats mapped on the pooled river reach (River Miles 202-301) included:

1. Main Channel,
2. Main Channel Border,
3. Side Channel,
4. Slough,
5. River Lake and Pond,
6. Tailwater, and
7. Navigation Pool.

The locations of dikes were also delineated, but dike fields were not mapped as independent habitats.

Acreages of aquatic habitats on the [illegible] (Section 3.[illegible]). The main channel border [illegible] type along the open river (approximately [illegible] percent of [illegible]) and [illegible]. The main channel [illegible] percent of the mapped habitat, and side channels [illegible].

The main channel habitat acreage varies between 23 and 51 percent of the aquatic habitat acreage in each of the 13 reaches of the open river that were mapped. The area of this habitat was influenced by the width of the river and the presence of dikes. Where no dikes were present, the main channel was mapped at a constant width of 400 feet.

The main channel border ranged from 38 to 60 percent of the available habitat acreage in each river reach with a mean of 32 percent. Side channel acreage averaged 9 percent of the available habitat and ranged from 0 to 21 percent. Habitat at the mouths of tributaries accounted for less than 1 percent of the available habitat in each river reach.

In the pooled river reach, the main channel border was also the most common habitat. Main channel border habitat ranged from 36 to 43 percent of the available habitat area. Side channel habitat in the pooled river ranged from 6 to 32 percent and averaged 23 percent of the mapped habitat.

Main channel habitat averaged 18 percent of the area mapped. Sloughs and river lakes each averaged 7 percent of the available habitat and they ranged from 3 to 12 percent and 2 to 10 percent, respectively.

A major difference between pooled and open river was in the acreage of main channel habitat. In the pooled river, the main channel constituted only 18 percent of the river acreage, but in the open river it represented almost 40 percent of the habitat. Side channels on the other hand accounted for 28 percent of the pooled river habitat area, but only approximately 10 percent of the open river habitats. These differences reflect the constricting effects of the channel control structures on the open river. The river has been reduced in width by these structures, but the main channel has not. Therefore, the main channel habitat represents a larger portion of the river acreage. The pooled river also has numerous dikes for controlling [illegible] does the open river; however, the large dams pool the water [illegible] the side channels and sloughs which are less common on the open river.

5.3 SEASONAL DIFFERENCES IN HABITAT

The distribution of aquatic organisms within a river system is affected by several factors, including substrates, cover, water quality (notably suspended sediments, point-source discharges, dissolved oxygen, and temperature), depth, current, and fluctuations in these habitat conditions. In the study area, high-water stage typically occurs from March through June in the tailwaters and on the open river. Low-water stage occurs from October through February. Water is generally held back during low water and released during high water in the navigation pools, causing less seasonal fluctuation in the pooled areas. Discharge is also high April through June and low, October through February. Turbidity is higher during periods of high discharge and lower during periods of low discharge. Temperatures vary seasonally, with the highest water temperatures occurring during July, August and September and the lowest temperatures occurring during December, January, February, and March.

During the spring and early summer when water levels are high, more of the floodplain is inundated. Side channels and sloughs are connected with the river and receive some flow. Also, more cover is available along the channel borders due to inundation of river bank vegetation. Periods of high discharge are associated with increased turbidity and scouring, particularly in the main channel and its borders. Increased turbidity reduces light penetration and photosynthesis, which affects the composition of phytoplankton, zooplankton and benthos (Schramm and Lewis, 1974). The distribution of fish is also affected by turbidity and flow. Increased current velocities and scouring will increase the catastrophic drift of benthic invertebrates.

Higher water temperatures result in lower dissolved oxygen levels, particularly in areas of little flow such as river lakes, sloughs, and, in cases of extremely low flow, some side channels. Low water levels

and discharges often occur during late fall and winter. Low water levels may result in sloughs and side channels becoming completely blocked off from the main river channel. Extreme low water levels may result in the main channel being the major [illegible] reducing its importance to aquatic biota.

Since sloughs and side channel water are generally more shallow, the water tends to cool quickly during the fall. These areas will freeze more quickly than areas that are deeper and faster moving. Low dissolved oxygen concentrations and perhaps fish kills are more likely during both summer stagnation and winter, if the areas become isolated. This is more likely to occur during periods of summer low flow in the [illegible] reach.

To summarize, spring and early summer tend to be times of high water, high discharge, high turbidity and moderate temperatures, providing the more favorable conditions for aquatic organisms in micro-channel areas, and less favorable conditions in the main river. Summer and early fall months tend toward higher temperatures, moderate discharge, and moderate depth, sometimes resulting in reduced availability of habitat suitable to aquatic organisms. Late fall and winter are generally times of low discharge, low water levels and cool water temperatures, sometimes resulting in unfavorable conditions for aquatic organisms in [illegible] the [illegible]. If oxygen levels become too low in [illegible], fish kills are more likely to be found in the side channels [illegible] during winter.

3.4 [illegible]

The pooled river differs from the open river in [illegible] width, quantity of [illegible] navigation. The open river has much higher [illegible] velocity than the pooled river due to 1) greater discharge [illegible] 3) narrower channels and 4) dikes which divert the flow of water from side channels and chutes, resulting in [illegible] depressed water elevations. Turbidity increased in the open river [illegible] primarily as inputs from the Missouri River. [illegible] water velocity in the pooled river [illegible] pool level is held above the natural level during low and intermediate river stages, decreasing the natural flow. [illegible] hinged [illegible] completely during natural high water stages, increasing water velocity to almost equal that of the open river. Erosion occurs upstream of the pool and sediment deposition occurs in the pool area. The downstream [illegible] (Rasmussen et al. 1979). [illegible] with sediment. [illegible]

Water level increases or decreases [illegible]

limiting in the main river habitats or in backwater areas where mixing occurs. However, backwaters with little mixing or current may experience oxygen reductions of biological significance on a diurnal or seasonal basis. This is most likely to occur on summer nights or during periods of winter ice-cover.

6.0 BENTHIC INVERTEBRATE AND FISHERIES RESULTS AND DISCUSSION

The goal of this section is to concisely characterize the biotic communities of the aquatic habitats within the GREAT III study area and, more importantly, to identify those communities and ecological features significant to, and associated with, each habitat type. Sections 6.1 and 6.2 provide brief synopses of dominant taxa, abundance, density, and other population parameters. The remaining sections describe biotic communities, population parameters, and key ecological features of each habitat and identify those habitats of significance from a biotic and/or ecological sensitivity standpoint.

6.1 SYNOPSIS OF BENTHIC INVERTEBRATE RESULTS

Table 6.1-1 lists the taxa collected during the study. Tables 6.1-2 through 6.1-5 present parameters of density (no./m^2), diversity (Shannon-Weaver), evenness, number of taxa, and number of individuals for each sampling area and each habitat. Table 6.1-6 summarizes benthic diversity and evenness data by habitat. Table 6.1-7 summarizes benthic density data by habitat. Appendix B contains a series of tables indicating seasonal occurrence of taxa and population parameters for each taxon by season, sampling area, and habitat.

All samples were collected with a petite Ponar dredge, which is effective only in soft substrates. No qualitative collections from hard substrates were made. Hard substrates typically can support more diverse benthic communities and taxa not found in soft substrates. Sampling hard substrates (e.g., rock riprap, logs, snags) during the course of the study probably would have increased overall diversity and taxonomic representation.

Benthic invertebrate data collected during the study consistently indicated numerical dominance of the benthos by Oligochaeta (worms) in all habitats and seasons. Overall, oligochaetes made up 75 to 80 percent of the total number of benthic organisms collected and 50 percent or more of nearly all individual samples.

Diptera (flies), notably of the families Chironomidae and Ceratapogonidae, were generally second in abundance and distribution. More than 35 species of chironomids were collected, indicating a diverse chironomid fauna. Ephemeroptera (mayflies), especially the genera Hexagenia and Pentagenia, were also common and quite widely distributed.

In addition, those habitats of reduced current and water depth which provided (or were in proximity to) hard or stable substrates yielded greater density and diversity of benthic fauna. Navigation pools, river lakes, sloughs, side channels, dike fields, and littoral zones were key benthic habitats.

Seasonal changes in the taxonomic composition and relative abundance of the benthos were not generally significant, due to the domination of the benthos by Oligochaeta during all sampling periods. Although total benthos density declined in fall and winter, the percent composition by Oligochaeta did not vary as greatly.

A majority of those taxa more closely associated with flowing waters, the Ephemeroptera, Trichoptera and Odonata, were more common during the fall and winter sampling periods due in part to 1) life cycle features, 2) overall reduction in high water levels, and 3) strong currents during spring and summer. Diptera taxa, although found commonly in all seasons, were reduced in occurrence and abundance during the winter sampling period, probably due to emergence.

Both the total number of taxa collected in each sampling area and the average number of taxa per habitat varied on a seasonal basis, although no distinct trends are evident. In general, the average number of taxa collected was greater in the summer and/or fall sampling period. The total number of taxa collected per sampling area was also generally greater in the summer and/or fall. These trends were not strong, and differences may not be statistically significant.

Although changes in taxonomic composition were not numerically significant, in most habitats or sampling areas, changes in composition and relative abundance were sufficient to cause changes in diversity. Natural population cycles and changing environmental conditions produced slight changes in composition but dramatic changes in density through the year.

In general, diversity increased through the summer and fall, with peaks in diversity variable depending upon habitat type. Density values regularly were highest in the spring sampling period and declined through the remainder of the sampling period.

Table 6.1-1. Taxa of Benthic Invertebrates, GREAT III Reach

Nematoda	(Roundworms)
Oligochaeta	(Aquatic earthworms)
Hirudinea	(Leeches)
Isopoda	(Aquatic sow bugs)
Asellus spp.	
A. intermedius	
Hydracarina	(Water mites)
Insecta	
Collembola	(Springtails)
Ephemeroptera	(Mayflies)
Potamanthidae	
Potamanthus spp.	
Ephemeridae	
Hexagenia spp.	
Hexagenia limbata	
Pentagenia vittigera	
Ephoron spp.	
Caenidae	
Caenis spp.	
Baetidae	
Baetis spp.	
Heptageniidae	
Stenonema spp.	
Odonata	(Dragonflies, Damselflies)
Gomphidae	
Dromogomphus spp.	
Coenagrionidae	
Argia spp.	
Hemiptera	(Bugs)
Corixidae	
Trichoptera	(Caddisflies)
Philopotamidae	
Neureclipsis spp.	
Hydropsychidae	
Potamyia flava	
Hydropsyche orris	
Cheumatopsyche spp.	
Leptoceridae	
Ceraclea spp.	
Coleoptera	(Beetles)
Hydrophilidae	
Berosus spp.	
Elmidae	
Stenelmis spp.	
Dubiraphia spp.	

Table 6.1-1. Taxa of Benthic Invertebrates, GREAT III Reach
(Continued, Page 2 of 3)

Diptera	(Flies)
Chaoboridae	(Phantom midges)
Chaoborus spp.	
Ceratopogonidae	(Biting midges)
Chironomidae	(Midges)
Tanypodinae	
Pentaneurini	
Pentaneura spp.	
P. flavifrons	
P. monilis	
Procladius spp.	
P. adumbratus	
Ablabesmyia spp.	
Tanypus spp.	
T. punctapennis	
Coelotanypodini	
Coelotanypus spp.	
C. concinnus	
Chironominae	
Chironomini	
Chironomus spp.	
C. riparius	
C. militaris	
C. decorus	
C. plumosus	
C. tentans	
C. cristatus	
Tendipes ferrineovittatus	
Xenochironomus spp.	
Harnischia spp.	
Robackia claviger	
Cryptochironomus spp.	
Parachironomus spp.	
Paracladopelma spp.	
Glyptotendipes spp.	
G. senilis	
Polypedilium spp.	
P. flavus	
Paralauterborniella spp.	
Dicrotendipes spp.	
Limnochironomus spp.	
L. modestus	

Table 6.1-1. Taxa of Benthic Invertebrates, GREAT III Reach (Continued, Page 3 of 3)

Tanytarsini	
Tanytarsus spp.	
Micropsectra spp.	
Orthocladiinae	
Cricotopus spp.	
Dolichopodidae	
Empididae	
Cyclorrhapha	
Gastropoda	(Snails)
Campeloma spp.	
Pelecypoda	(Clams, mussels)
Unionidae	(Mussels)
Quadrula quadrula	
Q. nodulata	
Truncilla truncata	
Sphaeriidae	(Fingernail clams)
Sphaerium spp.	
Musculium spp.	

Source: ESE, 1982.

Table 6.1-2. Seasonal Habitat Densities and Diversity of Benthic Invertebrates for the Winfield Sampling Area, GREAT III Reach

Habitat	Data	Spring	Summer	Fall	Winter
Navigation Pool (2)*	Density in $\#/m^2$	1392.00	14.00	531.00	[illegible]
	Shannon-Weaver Index (Evenness Index)	1.26 (1.13)	0.00 (0.00)	2.05 (2.15)	2.39 ([illegible])
	# of Taxa	13.00	1.00	9.00	15.00
	# of Individuals	97.00	1.00	37.00	[illegible]
Rivers, Ponds, and Lakes (3)*	Density in $\#/m^2$	2210.00	2856.00	No Sample	1119.00
	Shannon-Weaver Index (Evenness Index)	1.54 (1.61)	1.90 (1.76)		1.71 (2.20)
	# of Taxa	9.00	12.00		6.00
	# of Individuals	131.00	199.00		83.00
Sloughs (4)*	Density in $\#/m^2$	1952.00	2296.00	660.00	172.00
	Shannon-Weaver Index (Evenness Index)	1.32 (1.38)	0.25 (0.36)	0.29 (0.61)	1.50 (2.40)
	# of Taxa	9.00	5.00	3.00	4.00
	# of Individuals	136.00	160.00	46.00	12.00
Downstream End of Island (5)*	Density in $\#/m^2$	1320.00	373.00	14.00	273.00
	Shannon-Weaver Index (Evenness Index)	1.25 (1.61)	0.23 (0.76)	0.00 (0.00)	1.97 (2.33)
	# of Taxa	6.00	2.00	1.00	7.00
	# of Individuals	92.00	26.00	1.00	19.00
Dike Field (6)*	Density in $\#/m^2$	718.00	875.00	474.00	1019.00
	Shannon-Weaver Index (Evenness Index)	1.52 (2.52)	1.41 (1.48)	0.43 (1.43)	3.00 (2.44)
	# of Taxa	4.00	9.00	2.00	17.00
	# of Individuals	50.00	61.00	33.00	71.00
Main Channel Border Inside Bend (8)*	Density in $\#/m^2$	115.00	2109.00	2683.00	273.00
	Shannon-Weaver Index (Evenness Index)	1.85 (3.07)	2.17 (1.89)	0.29 (0.41)	2.37 (3.02)
	# of Taxa	4.00	14.00	5.00	8.00
	# of Individuals	8.00	147.00	187.00	19.00
Main Channel Border Outside Bend (9)*	Density in $\#/m^2$	502.00	301.00	1464.00	660.00
	Shannon-Weaver Index (Evenness Index)	0.22 (0.46)	2.02 (2.24)	0.42 (0.54)	0.70 (1.00)
	# of Taxa	3.00	4.00	6.00	1.00
	# of Individuals	35.00	21.00	102.00	46.00

Table 6.1-2. Seasonal Habitat Densities and Diversity of Benthic Invertebrates for the Winfield Sampling Area, GREAT III Reach (Continued, Page 2 of 2)

Habitat	Code	Spring	Summer	Fall	Winter
Main Channel Border Straight (10)*	Density in #/m²	2597.00	761.00	1995.00	1550.00
	Shannon-Weaver Index (Evenness Index)	0.35 (0.45)	2.02 (2.24)	0.42 (0.54)	0.70 (1.00)
	# of Taxa	6.00	8.00	6.00	5.00
	# of Individuals	181.00	53.00	139.00	108.00
Side Channel (11)	Density in #/m²	215.00	14.00	847.00	545.00
	Shannon-Weaver Index (Evenness Index)	2.26 (2.90)	0.00 (0.00)	0.21 (0.70)	1.29 (2.70)
	# of Taxa	6.00	1.00	2.00	3.00
	# of Individuals	15.00	1.00	59.00	38.00
Natural Littoral (12)*	Density in #/m²	6486.00	4133.00	780.00	301.00
	Shannon-Weaver Index (Evenness Index)	0.14 (0.29)	0.36 (0.42)	0.34 (0.71)	0.00 (0.00)
	# of Taxa	3.00	7.00	3.00	1.00
	# of Individuals	452.00	288.00	55.00	21.00
Revetted Littoral (13)*	Density in #/m²	1622.00	4592.00	517.00	[illegible]
	Shannon-Weaver Index (Evenness Index)	0.28 (0.59)	1.49 (1.38)	1.34 (1.92)	1.31 (1.68)
	# of Taxa	3.00	12.00	5.00	6.00
	# of Individuals	113.00	320.00	36.00	51.00
	Average Density in #/m²	1739.00	1666.00	992.00	856.00
	Average Shannon-Weaver Index (Evenness Index)	1.09 (1.46)	1.06 (1.20)	0.66 (0.92)	1.51 (1.81)
	Total # of Taxa	30.00	35.00	21.00	36.00
	Average # of Individuals	119.10	116.10	63.80	59.60
	Average # of Taxa	6.0	7.0	4.0	[illegible]

* Indicates habitat codes and sampling sites.

Source: [illegible], 1982.

Table 6.1-3. Seasonal Habitat Densities and Diversity of Benthic Invertebrates for the Clarksville Sampling Area, GREAT III Reach

Habitat	Code	Spring	Summer	Fall	Winter
Navigation Pool (2)*	Density in #/m^2	2038.00	115.00	531.00	1234.00
	Shannon-Weaver Index (Evenness Index)	0.46 (0.96)	0.00 (0.00)	1.47 (2.10)	[illegible]
	# of Taxa	3.00	1.00	5.00	14.00
	# of Individuals	142.00	8.00	37.00	86.00
Rivers, Ponds, and Lakes (3)*	Density in #/m^2	1076.00	1521.00	488.00	603.00
	Shannon-Weaver Index (Evenness Index)	0.84 (1.39)	2.61 (2.28)	1.95 (2.30)	0.53 (1.11)
	# of Taxa	4.00	14.00	6.00	3.00
	# of Individuals	75.00	106.00	34.00	42.00
Sloughs (4)*	Density in #/m^2	2526.00	No Sample	2856.00	No Sample
	Shannon-Weaver Index (Evenness Index)	1.86 (1.79)		1.05 (1.10)	
	# of Taxa	11.00		9.00	
	# of Individuals	176.00		199.00	
Downstream End of Island (5)*	Density in #/m^2	3803.00	3401.00	1248.00	1421.00
	Shannon-Weaver Index (Evenness Index)	0.46 (0.59)	0.88 (1.04)	0.62 (1.30)	0.66 (1.08)
	# of Taxa	6.00	7.00	3.00	4.00
	# of Individuals	256.00	237.00	87.00	99.00
Dike Field (6)*	Density in #/m^2	2727.00	1392.00	1923.00	287.00
	Shannon-Weaver Index (Evenness Index)	1.14 (1.26)	1.50 (1.50)	1.40 (1.30)	0.55 (1.15)
	# of Taxa	8.00	10.00	12.00	3.00
	# of Individuals	190.00	97.00	134.00	20.00
Main Channel Border Inside Bend (8)*	Density in #/m^2	1507.00	344.00	2052.00	1134.00
	Shannon-Weaver Index (Evenness Index)	0.53 (0.76)	0.63 (2.09)	0.81 (0.96)	1.12 (1.17)
	# of Taxa	5.00	2.00	7.00	9.00
	# of Individuals	105.00	24.00	143.00	79.00
Main Channel Border Outside Bend (9)*	Density in #/m^2	1177.00	3544.00	1320.00	2421.00
	Shannon-Weaver Index (Evenness Index)	1.63 (2.09)	1.27 (1.14)	1.66 (1.59)	2.15 (2.15)
	# of Taxa	6.00	13.00	11.00	10.00
	# of Individuals	82.00	247.00	92.00	99.00

Table 6.1-3. Seasonal Habitat Densities and Diversity of Benthic Invertebrates for the Clarksville Sampling Area, GREAT III Reach (Continued, Page 2 of 2)

Habitat	Code	Spring	Summer	Fall	Winter
Main Channel Border Straight (10)*	Density in #/m^2	517.00	29.00	129.00	1205.00
	Shannon-Weaver Index (Evenness Index)	0.70 (1.00)	0.00 (0.00)	0.97 (3.22)	2.50 (1.99)
	# of Taxa	5.00	1.00	2.00	18.00
	# of Individuals	36.00	2.00	6.00	86.00
Side Channel (11)*	Density in #/m^2	2124.00	1650.00	1091.00	617.00
	Shannon-Weaver Index (Evenness Index)	0.32 (2.32)	0.00 (0.00)	0.99 (3.23)	0.15 (2.51)
	# of Taxa	2.00	1.00	6.00	2.00
	# of Individuals	148.00	115.00	76.00	43.00
Natural Littoral (12)*	Density in #/m^2	2124.00	1650.00	1091.00	617.00
	Shannon-Weaver Index (Evenness Index)	0.32 (1.06)	0.00 (0.00)	0.99 (1.27)	0.15 (0.50)
	# of Taxa	2.00	1.00	6.00	2.00
	# of Individuals	148.00	115.00	76.00	43.00
Revetted Littoral (13)*	Density in #/m^2	588.00	1665.00	172.00	631.00
	Shannon-Weaver Index (Evenness Index)	1.55 (1.62)	1.29 (1.20)	1.37 (2.27)	1.55 (1.99)
	# of Taxa	9.00	12.00	4.00	6.00
	# of Individuals	41.00	116.00	12.00	44.00
	Average Density in #/m^2	1722.00	1143.00	971.00	894.00
	Average Shannon-Weaver Index (Evenness Index)	1.01 (1.35)	0.82 (0.92)	1.26 (1.[illegible])	1.37 (1.56)
	Total # of Taxa	30.00	36.00	[illegible]	36.00
	Average # of Individuals	120.00	95.80	[illegible]	62.30
	Average # of Taxa	6.00	6.00	[illegible]	8.00

*[illegible] habitat code at sampling site.

[illegible], 1982.

Table 6.1-4. Seasonal Habitat Densities and Diversity of Benthic Invertebrates for the Ste. Genevieve Sampling Area, GREAT III Reach

Habitat	Code	Spring	Summer	Fall	Winter
Main Channel Border Inside Bend (8)*	Density in #/m^2	172.00	775.00	144.00	86.00
	Shannon-Weaver Index (Evenness Index)	1.17 (1.94)	0.44 (0.92)	0.00 (0.00)	1.21 (2.54)
	# of Taxa	4.00	3.00	1.00	3.00
	# of Individuals	12.00	54.00	10.00	6.00
Main Channel Border Outside Bend (9)*	Density in #/m^2	43.00	57.00	172.00	43.00
	Shannon-Weaver Index (Evenness Index)	1.54 (3.23)	0.00 (0.00)	1.17 (1.94)	0.89 (2.96)
	# of Taxa	3.00	1.00	4.00	2.00
	# of Individuals	3.00	4.00	12.00	3.00
Main Channel Border Straight (10)*	Density in #/m^2	14.00	100.00	100.00	0.00
	Shannon-Weaver Index (Evenness Index)	0.00 (0.00)	1.79 (2.97)	2.06 (2.95)	0.00 (0.00)
	# of Taxa	1.00	4.00	5.00	0.00
	# of Individuals	1.00	7.00	7.00	0.00
Side Channel (11)*	Density in #/m^2	2655.00	57.00	No Sample	14.00
	Shannon-Weaver Index (Evenness Index)	0.33 (0.47)	1.94 (3.22)		0.00 (0.00)
	# of Taxa	5.00	4.00		1.00
	# of Individuals	185.00	4.00		1.00
Natural Littoral (12)*	Density in #/m^2	14.00	761.00	0.00	43.00
	Shannon-Weaver Index (Evenness Index)	0.00 (0.00)	0.43 (0.90)	0.00 (0.00)	0.00 (0.00)
	# of Taxa	1.00	3.00	0.00	1.00
	# of Individuals	1.00	53.00	0.00	3.00
Revetted Littoral (13)*	Density in #/m^2	No Sample	0.00	29.00	0.00
	Shannon-Weaver Index (Evenness Index)		0.00 (0.00)	1.33 (4.42)	0.00 (0.00)
	# of Taxa		0.00	2.00	0.00
	# of Individuals		0.00	2.00	0.00

Table 6.1-5. Seasonal Habitat Densities and Diversity of Benthic Invertebrates for the Cape Girardeau Sampling Area, [illegible] Reach

Habitat	Code	Spring	Summer	Fall	Winter
Main Channel Border Inside Bend (8)*	Density in #/m^2	14.00	No Sample	43.00	0.00
	Shannon-Weaver Index (Evenness Index)	0.00 (0.00)		0.00 (0.00)	0.00 (0.00)
	# of Taxa	1.00		1.00	0.00
	# of Individuals	1.00		3.00	0.00
Main Channel Border Outside Bend (9)*	Density in #/m^2	172.00	No Sample	359.00	43.00
	Shannon-Weaver Index (Evenness Index)	0.40 (1.33)		0.00 (0.00)	1.58 (3.23)
	# of Taxa	2.00		1.00	3.00
	# of Individuals	12.00		25.00	3.00
Main Channel Border Straight (10)*	Density in #/m^2	230.00	No Sample	187.00	43.00
	Shannon-Weaver Index (Evenness Index)	0.00 (0.00)		0.00 (0.00)	0.89 (2.96)
	# of Taxa	0.00		1.00	2.00
	# of Individuals	16.00		13.00	3.00
Side Channel (11)*	Density in #/m^2	459.00	1464.00	330.00	402.00
	Shannon-Weaver Index (Evenness Index)	1.53 (2.19)	1.04 (1.15)	0.25 (0.83)	1.85 (2.65)
	# of Taxa	5.00	8.00	2.00	5.00
	# of Individuals	32.00	102.00	23.00	29.00
Natural Littoral (12)*	Density in #/m^2	14.00	0.00	14.00	187.00
	Shannon-Weaver Index (Evenness Index)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.11 (1.84)
	# of Taxa	1.00	0.00	1.00	4.00
	# of Individuals	1.00	0.00	1.00	13.00
Revetted Littoral (13)*	Density in #/m^2	144.00	14.00	387.00	86.00
	Shannon-Weaver Index (Evenness Index)	0.00 (0.00)	0.00 (0.00)	0.80 (1.33)	0.63 (2.09)
	# of Taxa	1.00	1.00	4.00	2.00
	# of Individuals	10.00	1.00	27.00	6.00

Table 6.1-5. Seasonal Habitat Densities and Diversity of Benthic Invertebrates for the Cape Girardeau Sampling Area, GREAT III Reach (Continued, Page 2 of 2)

Habitat	Code	Spring	Summer	Fall	Winter
Pile Dike (14)*	Density in #/m^2	373.00	804.00	646.00	14.00
	Shannon-Weaver Index (Evenness Index)	0.23 (0.76)	0.63 (1.05)	0.55 (0.91)	0.00 (0.00)
	# of Taxa	2.00	4.00	4.00	1.00
	# of Individuals	26.00	56.00	45.00	1.00
Stone Dike (15)*	Density in #/m^2	58.00	416.00	14.00	158.03
	Shannon-Weaver Index (Evenness Index)	1.94 (3.22)	0.80 (1.68)	0.00 (0.00)	1.24 (2.06)
	# of Taxa	4.00	3.00	1.00	4.00
	# of Individuals	4.00	29.00	1.00	11.00
	Average Density in #/m^2	183.00	540.00	248.00	117.00
	Average Shannon-Weaver Index (Evenness Index)	0.51 (0.94)	0.49 (0.78)	0.20 (0.38)	0.91 (1.85)
	Total # of Taxa	9.00	11.00	7.00	12.00
	Average # of Individuals	2.00	3.60	2.00	3.00
	Average # of Taxa	13.00	38.00	17.00	8.00

* Indicates habitat number and sampling site.

Source: ESE, 1982.

Table 6.1-6. Summary of Benthic Diversity†† Data by Habitat, GREAT III Reach

Habitat	Composite Diversity*				Average Diversity†		
	Clarksville	Winfield	Ste. Genevieve	Cape Girardeau	Pooled River	Open River	Overall
Tailwater	**	**	**	**	**	**	**
Navigation Pool	1.51 (1.20)	2.35 (1.62)	**	**	1.93 (1.41)	**	1.93 (1.41)
River Lake	1.97 (1.57)	2.31 (1.75)	**	**	2.16 (1.66)	**	2.16 (1.66)
Slough	1.67 (1.36)	1.25 (1.06)	**	**	1.46 (1.21)	**	1.46 (1.21)
Downstream-End-of-Island	0.82 (0.74)	1.40 (1.40)	**	**	1.11 (1.07)	**	1.11 (1.07)
Dike Field	1.57 (1.15)	2.39 (1.81)	1.91 (2.11)	1.36 (1.61)	1.98 (1.48)	1.64 (1.86)	1.81 (1.67)
Main Channel	**	**	**	**	**	**	**
Main Channel Border-Inside Bend	1.01 (0.82)	1.81 (1.35)	0.76 (0.90)	0.81 (1.70)	1.41 (1.08)	0.79 (1.30)	1.10 (1.19)
Main Channel Border-Outside Bend	2.06 (1.51)	0.92 (0.96)	1.96 (2.17)	0.50 (0.83)	1.49 (1.26)	1.23 (1.50)	1.36 (1.37)
Main Channel Border-Straight	2.34 (1.77)	0.91 (0.76)	2.33 (2.75)	0.26 (0.54)	1.63 (1.27)	1.30 (1.64)	1.47 (1.46)
Side Channel	2.34 (2.04)	1.63 (1.56)	0.56 (0.59)	1.48 (1.42)	1.99 (1.80)	1.02 (1.00)	1.51 (1.40)
Natural Littoral	0.47 (0.52)	0.23 (0.23)	0.56 (0.93)	1.07 (1.78)	0.35 (0.38)	0.82 (1.36)	0.59 (0.87)
Revetted Littoral	2.06 (1.67)	1.42 (1.11)	0.97 (3.22)	0.83 (1.19)	1.74 (1.39)	0.90 (2.20)	1.32 (1.80)
Pile Dike	**	**	2.27 (2.69)	0.62 (0.73)	**	1.45 (1.71)	1.45 (1.71)
Mouth of Tributary	**	**	**	**	**	**	**
MEAN	2.80 (1.30)	1.93 (1.24)	1.13 (1.92)	0.87 (1.22)	1.57 (1.27)	1.14 (1.57)	1.44 (1.42)

* Composite Diversity—Calculated by combining all data from all seasons prior to calculating diversity value.
† Average Diversity—Mathematical Average.
** Habitat not sampled.
†† Diversity — Shannon-Weaver Index and (Evenness Index)

Source: ESE, 1982.

Table 6.1-7. Summary of Benthic Invertebrate Density Data (No. organisms/m^2) by Habitat, GREAT III Reach

Habitat	Season Average				Pooled River Average	Open River Average	Overall Average
	Clarksville	Winfield	Ste. Genevieve	Cape Girardeau			
Tailwater	--*	--	--	--	--	--	--
Navigation Pool	979	1,159	--	--	1,069	--	1,069
River Lake	922	2,085	--	--	1,503	--	1,503
Slough	2,691	1,270	--	--	1,980	--	1,980
Downstream-End-of-Island	2,468	495	--	--	1,481	--	1,481
Dike Field	1,582	771	366	161	1,177	263	720
Main Channel	--	--	--	--	--	--	--
Main Channel Border-Inside Bend	1,259	1,295	294	19	1,277	157	717
Main Channel Border-Outside Bend	1,865	732	79	191	1,299	135	717
Main Channel Border-Straight	470	1,726	53	153	1,098	103	600
Side Channel	574	405	909	664	489	787	638
Natural Littoral	1,370	2,927	205	54	2,149	129	1,139
Revetted Littoral	764	1,866	10	158	1,315	84	699
Pile Dike	--	--	153	459	--	306	306
Mouth of Tributary	--	--	--	--	--	--	--
MEAN	1,359	1,339	259	232	1,349	245	964

* Habitat not sampled.

Source: [illegible], 1982.

6.2 SYNOPSIS OF FISHERIES DATA

Quarterly field sampling efforts during the study yielded 22,574 fish. Sixty-nine identifiable taxa were represented (Table 6.2-1). Table 6.2.2 presents the fish categories utilized in subsequent discussions and indicates the species in each category. Table 6.2-3 lists by sampling area the number and relative abundance (percent) of all fish taxa collected. In terms of relative abundance in the total catch, gizzard shad (Dorosoma cepedianum) was the dominant species (36.8 percent). Carp (Cyprinus carpio) was second in relative abundance (12.9 percent). Other abundant taxa included emerald shiner (Notropis atherinoides) at 10.4 percent, freshwater drum (Aplodinotus grunniens) at 6.2 percent, and river shiner (Notropis blennius) at 4.1 percent.

Electroshocking collections produced 54 percent of the fish collected in the study, while trammel netting and trawling each produced less than 1 percent of the fish collected. Electrofishing effectively captured many species of fish during the study. Seining was principally effective for cyprinids and young-of-the-year gizzard shad, freshwater drum, and channel catfish. Frame netting collected large numbers of gizzard shad, freshwater drum, bluegill, shortnose gar, black crappie, white bass, and white crappie. Gill netting collected numerous gizzard shad, carp, shortnose gar, black bullhead, goldeye, and shovelnose sturgeon. Fishes collected in large numbers by hoop nets included freshwater drum, flathead catfish, gizzard shad, and black crappie. Trammel net sampling, although collecting only 76 fish during the entire study, resulted in smallmouth buffalo and river carpsucker comprising a large percentage of the fishes collected by this method. Trawling also produced few fishes during the collection. Young-of-the-year channel catfish, as well as speckled chub and shovelnose sturgeon numerically dominated the trawl collections (Table 6.2-4). These species were most abundant in the Winfield and Clarksville collections.

Tables 6.2-5 through 6.2-8 list the number of each taxon collected at each sampling area, by habitat. Tables 6.2-9 and 6.2-10 provide summaries of catch-per-unit-effort and of diversity, by habitat. Gizzard shad, carp, and emerald shiner were collected at all sampling sites and all habitats. Twenty-five of the 69 taxa (including 19 of the 21 most abundant taxa) were collected at all four sampling areas. Table 6.2-11 lists habitat associations of fish species on the GREAT III Reach. Table 6.2-12 presents major fish species associated with each habitat at the GREAT III Reach.

Comparing the total fish collection from the pooled river with that of the open river, approximately 40 percent more species and 50 percent more individuals were collected in the pooled river.

As was found for the benthic invertebrate community, the more productive and diverse fishery existed in those habitats of reduced current and depth with some cover in the form of snags, logs, or aquatic macrophytes. Therefore, key fishery habitats were found to be navigation pools, river lakes, sloughs, side channels, and dike fields.

Fish collections were conducted April through early December 1981. Sampling was underway at one or more sites almost continuously throughout the study period. This sampling regime resulted in samples collected at widely spaced intervals at each site and habitat. Direct seasonal comparisons between sampling sites or within sampling sites are therefore not well defined.

Electrofishing at the four sampling sites during the summer sampling period (second sampling period) produced fewer fish than the other three periods (Tables C-1, C-2, C-3, and C-4). Species with low summer electrofishing collections, compared to the other seasons, were gizzard shad, carp, largemouth bass, and white bass. Species with autumn (third collection period) electrofishing catches different from other seasons

were channel catfish (which were collected in lower numbers) and flathead catfish (which were collected in higher numbers). Other seasonal electrofishing catch differences included reduced shortnose gar collections in the winter, increased goldeye catches in the winter, and reduced bluegill catches in the summer and autumn. Species commonly collected by electrofishing that showed little seasonal catch variation included freshwater drum, bigmouth buffalo, and smallmouth buffalo.

Frame net sampling produced fewer species than electrofishing collections did. Abundant species in frame net collections whose catch varied seasonally were shortnose gar, gizzard shad, bluegill and black crappie. Catches of shortnose gar were reduced during the fall. Frame net collections of bluegill were reduced during the autumn, while black crappie collections were particularly high during the summer.

Gill net and frame net collections were generally limited to four habitats at the pooled sites. Additional gill net collections were made during the final sampling period in place of trammel net sampling at all sampling sites. The increased number of total fishes collected during this period was primarily due to a large increase in the number of gizzard shad collected by gill netting. Other abundant taxa in the gill net collections, including shortnose gar, carp, and buffalo, exhibited similar seasonal catch rates. The black bullhead catch rate fell during the final sampling period, primarily due to a reduced catch at the Winfield river lake.

Hoop net sampling resulted in similar catch rates during all sampling seasons. The largest species catch rate difference was that of the flathead catfish, which were captured in large numbers during the summer sampling period. The remaining species were collected either in low numbers or in similar numbers during all sampling seasons.

Catches were low during the three seasons during which trammel nets were used. Collections were highest during the spring, primarily due to a

higher than average number collected at the pooled river sites. Differences between species-specific seasonal catch rates in trammel nets were not evident from the data collected.

Collections from seine samples were variable based upon the river stage and the availability of shallow sand and/or mud bar habitat within the study areas. Collections made during the final sampling season were much larger than in other seasons, due to low river stages providing more area to sample efficiently. The final sampling period also included the period after spring and early summer spawning when cypriinids and young-of-the-year fishes are most abundant.

Trawling collections resulted in the capture of few fishes during the study. Catch rate trends paralleled those encountered during seine collection. Trawl collections were highest during the fall and winter sampling periods. Fishes collected in trawls are frequently small, bottom dwelling fish such as young-of-the-year catfishes, and freshwater drum, as well as cypriinids, including speckled and silver chubs (LGL, Associates, 1981). These fishes, particularily the young-of-the-year, are most abundant during the late summer and autumn months.

Seasonal differences were evident in the collections of a number of species using a variety of sampling methods. Species-specific catch rates were evidently influenced by the general activity of fishes, which influences sampling with passive collection methods such as gill netting, frame netting, and hoop netting. Active collection methods are influenced by the availability of fishes within the zone of collection efficiency for the active collection techniques which included electrofishing, seining, and trawling.

Seasonal weather conditions, as well as short-term weather conditions, may have influenced the catch rates. Periods of cold weather and low barometric pressure can reduce fish movement, resulting in fewer fishes collected by passive techniques. Conversely, during periods when

spawning fishes are congregating, the increased amount of these fishes can increase catches using both passive and active collection methods. Active methods also can be affected by seasonal and short term weather activity. Cold weather, extremely warm weather, or low barometric pressure can act to congregate some fishes in deeper water areas, away from the zones of effective collection for electrofishing or seining.

It appears that short-term as well as seasonal physical conditions (weather, river stage, etc.) influenced the observed differences among capture rates for different species. However, specific trends cannot be determined due to the almost continuous sampling program utilized during the study.

6.2.1 LENGTH-FREQUENCY ANALYSIS

Twelve species of fish were selected for analysis based upon their overall abundance and their importance to commercial and sport fisheries within the GREAT III study reach. The selected species are:

- Channel catfish
- Freshwater drum
- Carp
- Gizzard shad
- Largemouth bass
- White crappie
- Black crappie
- White bass
- Shortnose gar
- Bluegill
- Smallmouth buffalo
- Flathead catfish

Tables D-1 through D-12 provide length-frequency summaries of each of the selected species at all habitats sampled. Tables D-13 through [illegible]

provide length-frequency summaries of the remaining species collected during the study.

Channel Catfish

The mean total length of channel catfish collected during the investigations, at all habitats sampled, was 245 mm (Table D-1). Habitats exhibiting the highest mean total lengths of channel catfish collected were stone dike (open river), revetted littoral (pooled river), slough (pooled river), and outside bend (open river). In both the pooled and open rivers, habitats with low mean total lengths of channel catfish collected were the natural littoral and main channel habitats, where lower lengths were primarily due to exclusive utilization of seining (natural littoral) and trawling (main channel) as collection techniques. (These methods tend to be selective toward smaller fishes.) The collection of numerous small (young-of-the-year) channel catfish at these habitats, particularily at the natural littoral habitat, indicates their importance as nursery areas for channel catfish. Other habitats (side channel and main channel border) may also be important nursery areas (Bertrand and Lockart 1973; Bertrand and Garver 1973), but sampling gear selectivity may not have determined adequately the presence of young channel catfish at these habitats.

Freshwater Drum

At all habitats sampled, the mean total length of freshwater drum collected during the investigations, was 209 mm (Table D-2). Habitats exhibiting the highest mean total lengths of freshwater drum collected were outside bend channel border (open river), inside bend channel border (open river), straight stretch channel border (open river), and slough (pooled river). Smallest mean total lengths were collected at the natural littoral habitat at the pooled and open river areas. The collection of most of the small (young-of-the-year) specimens at the natural littoral habitat is indicative of 1) the sampling methodology utilized (seining was undertaken only at the natural littoral habitat, and 2) the importance of this habitat as a nursery area. Other areas

(side channel and main channel border) may be important nursery areas (Bertrand and Allen, 1973; Bertrand and Garver, 1973; Bertrand and Lockart, 1973) but were not documented in the GREAT III collections.

Carp

At all habitats sampled, carp mean total length was 432 mm during the GREAT III investigations (Table D-3). Typically, the majority of carp collected during the study ranged from 300 to 650 mm in length. Few small individuals (less than 200 mm) were collected during the study. The majority of small individuals in the collections were taken from slack water habitats, including natural littoral, river lake, navigation pool, and mouth of tributary habitats. These and other reduced current areas (side channels, sloughs, etc.) apparently are utilized as spawning and nursery areas (Bertrand and Allen, 1973; Farabee, 1979).

The mean total length of carp collected at the different habitats was generally similar. Habitats producing catches with the highest mean total lengths were outside bend channel border (open river), inside bend channel border (open river), inside bend channel border (pooled river), and stone dike habitat (open river). The habitat producing the smallest mean total length collections was the river lake (pooled river). This small total length was apparently due to the larger number of small carp in the collections from this habitat.

Collections of carp at habitats common to both sections of the river indicate that mean length is similar at all habitats. Open river mean lengths were highest at the revetted littoral, inside bend main channel border, and outside bend channel border habitats. Pooled river mean lengths were highest at straight stretch channel border, side channel, and natural littoral habitats. The difference between mean total lengths, however, is small and apparently insignificant.

Gizzard Shad

Gizzard shad were collected at all sampling habitats in the pooled and open river. Gizzard shad mean total length at all habitats was 201 mm. Shad collected ranged between 25 and 475 mm, with most shad ranging from 75 to 350 mm in total length (Table D-4).

Habitats exhibiting the highest mean total length were dike field (pooled river), inside bend channel border (pooled river), and inside bend channel border (open river). In both the pooled and open rivers, habitats with low mean total lengths of gizzard shad were natural and revetted littoral habitats. This lower length at these habitats is apparently due to the collection of small individuals in the seine collections at the natural littoral habitat and the collection of fewer large shad at both habitats. The collection of small, young-of-the-year, shad at the natural littoral habitat and the preference of gizzard shad for shallow slack current areas for spawning (Pflieger, 1975), suggest that littoral (natural and revetted), sloughs, river lakes, side channels, and other reduced current areas are important nursery areas for juvenile shad.

Largemouth Bass

Largemouth bass were collected at 8 of the 13 pooled river habitats and 2 of the 10 open river habitats. The mean total length of largemouth bass collected during the study was 263 mm (Table D-5).

Habitats which produced more than 5 bass in the collections were navigation pool, river lake, and slough (all pooled river habitats). The mean total length of largemouth bass from these three habitats was similar, with those from the river lake being slightly longer.

Few small bass (150 mm or less--young-of-the-year) were collected during the study. In reduced current areas with numerous stumps and weeds where adult and young-of-the-year largemouth bass are typically most common (Farabee, 1979), collection methods utilized were unsuccessful in

capturing juvenile bass. However, based upon habitat requirements, it is believed that juvenile bass would most likely be abundant in river lake, slough, and navigation pool habitats.

White Crappie

The mean total length of white crappie collected during the study, from all habitats sampled was 207 mm (Table D-6). Habitats producing more than ten specimens in the collections were river lake, tailwater, navigation pool, slough (all pooled river habitats), and mouth of tributary (open river). The mean total length of white crappies from these habitats was similar, ranging from 186 to 214 mm.

Few young-of-the-year white crappie (less than 100 mm) were collected during the study. Habitats producing young-of-the-year crappies in the collections were river lake, navigation pool, and tailwater habitats. Additional potential nursery areas for crappies include sloughs, side channels, and main channel borders (Bertrand and Garver, 1973; Bertrand and Allen, 1973; Hall, 1980).

Black Crappie

Black crappie mean total length from all habitats sampled was 182 mm (Table D-7). Black crappie were more abundant than white crappie in the collections. White crappie mean total length was longer than black crappie total length. Seventy-six percent of the black crappies collected during the study were collected at the river lake habitat.

Habitats producing more than ten specimens in the sample collections were river lake, slough, side channel, navigation pool, and dike field habitats (all pooled river habitats). The mean total length of black crappies from these habitats ranged from 175 to 230 mm.

Few young-of-the-year black crappie (less than 100 mm) were collected during the study. Juvenile black crappies were collected at river lake

and stone dike habitats. Additional potential crappie nursery areas are mentioned in the section on white crappie.

White Bass

White bass mean total length at all habitats sampled was 224 mm (Table D-8). Habitats exhibiting highest mean total lengths of white bass were outside bend channel border (pooled river), straight stretch channel border (pooled river), dike field (pooled river), and stone dike (open river) (includes only those habitats with collections producing 10 or more white bass). Habitats with low mean total lengths of white bass collected were the natural littoral (open and pooled rivers), river lake (pooled river), and navigation pool (pooled river). The lower lengths were primarily due to the collection of more small white bass (less than 100 mm) at these habitats than at the remaining habitats. The collection of small, young-of-the-year, white bass at these habitats is indicative of the importance of these habitats as nursery areas as well as use of seining at the natural littoral habitat. Additional potential nursery areas include tailwaters, main channel border, and side channel habitats (Bertrand and Allen, 1973; Bertrand and Lockart, 1973).

Shortnose Gar

Shortnose gar were present in collections from all habitats sampled in the pooled and open river, except at the main channel. Shortnose gar mean total length at all habitats sampled was 517 mm (Table D-9). The majority of gar collected during the study ranged between 400 and 630 mm in length. Few small individuals (less than 200 mm) were collected during the study. The two young-of-the-year individuals collected during the study were collected at the natural littoral habitat (open river). The preference for slackwater habitats with vegetation for spawning as well as adult habitat (Pflieger, 1975) indicates that, in addition to natural littoral habitats, other areas such as sloughs, river lakes, and side channels may be important spawning and nursery areas for shortnose gar.

Bluegill

Bluegill were collected at 6 of the 10 open river habitats and 11 of the 13 pooled river habitats. The mean total length of bluegill collected during the study was 125 mm (Table D-10). Habitats which produced more than 5 bluegill in the collections were river lake, slough, navigation pool, dike field, natural littoral (all pooled river), and natural littoral (open river). Sixty-nine percent of the bluegill collected during the study were collected at the river lake habitat.

Young-of-the-year bluegill were most abundant at those habitats exhibiting the largest sample collections (river lake, slough, navigation pool, and natural littoral habitats). This is indicative of the importance of shallow river lake and slough habitat for adult and young bluegill (Farabee, 1979).

Smallmouth Buffalo

The mean total length of smallmouth buffalo collected during the study, at all habitats sampled, was 297 mm (Table D-11). Habitats exhibiting the highest mean total lengths of smallmouth buffalo were the side channel (open river), straight stretch channel border (pooled river), and outside bend channel border (pooled river). Habitats exhibiting lower mean total lengths were the navigation pool and natural littoral habitats in the pooled river.

Few small smallmouth buffalo (125 mm or less--young-of-the-year) were collected during the study. These young buffalo were collected at natural littoral, river lake, and slough habitats. These and other shallow water areas are apparently important nursery habitats for smallmouth buffalo (Farabee, 1979).

Flathead Catfish

The mean total length of flathead catfish collected during the investigation, at all habitats sampled, was 320 mm (Table D-12). Habitats exhibiting the highest mean total lengths of flathead catfish

border (open and pooled river), outside bend channel border (open river), and inside bend channel border (open river). Habitats exhibiting lower mean total lengths were the outside bend channel border (pooled river), inside bend channel border (pooled river), and revetted littoral (pooled river).

Few young-of-the-year flathead catfish (125 mm or less) were collected during the study. Habitats at which young were collected were outside bend channel border (pooled river), inside bend channel border (pooled river), and revetted littoral (pooled and open river). Pflieger (1975) indicates that young are found among rocks on riffles.

6.2.2 CHEMOFISHING

Table 6.2-13 indicates the taxa, number and standing crop (lb/acre) of fish collected by chemofishing. Table 6.2-14 provides additional data on length and weight ranges and means. A total of 27,458 fish representing 35 taxa, weighing 10,649 lbs or 5.3 tons (4,824 kg) was collected by chemofishing in the Kaskaskia side channel. The dominant taxa in the collections were carp (1,147 fish weighing 3,305 lbs (1,497 kg)); gizzard shad (23,359 fish weighing 2,631 lbs (1,192 kg)); buffalo (Ictiobus spp.) (693 fish weighing 2,313 lbs (1,048 kg)); and gar (Lepisosteus spp.) (1,257 fish weighing 1,637 lbs (737 kg)). In addition, two species not collected at any site during the major sampling phase of the study were gathered during chemofishing. These species were paddlefish and grass carp (white amur). Other investigators have found that recovery rates in similar chemofishing studies in the Upper Mississippi River ranged between 56 to 75 percent (ERT, 1982). This would suggest that our data are an underestimation of biomass.

The most abundant species, by number, in the chemofishing collections in order of abundance were gizzard shad, gar (mostly shortnose gar), carp, buffalo (mostly bigmouth buffalo), freshwater drum, channel catfish, and carpsucker (mostly river carpsuckers).

Taxa contributing the greatest weight to the total biomass in order, were carp, gizzard shad, buffalo, gar, carpsucker, channel catfish, freshwater drum, and white bass.

It is apparent from the large number, biomass, and diversity of fish collected during the chemofishing survey that the side channel habitat surveyed is very productive and plays an important role in the aquatic ecology of the open river. In fact, more fish were collected by chemofishing at the Kaskaskia side channel than were collected during the entire GREAT III biological survey at all four sampling sites.

The chemofishing collections produced two species not collected at any site during the GREAT III collections (paddlefish and grass carp) as well as 3 species (green sunfish, orangespotted sunfish, and walleye), excluding cyprinids, that were not collected at the Ste. Genevieve side channel prior to chemofishing. Additionally, 2 species (skipjack herring and redear sunfish) were previously collected at the side channel habitat but were not collected during the chemofishing survey. However, in all cases the species differences between chemofishing and normal sampling periods involved uncommon species collected in low numbers.

Species which were common in chemofishing and normal sampling periods included gizzard shad, carp, gar, and buffalo. Sampling during normal periods, however, did not reveal the extremely high numbers of fish such as buffalo (particularly bigmouth buffalo) and gar that the chemofishing sampling did. It would appear that chemofishing is more effective than other sampling methods. Species composition and abundance may vary according to changes in habitat conditions caused by fluctuations in current velocity. During periods of high flow, species associated with these conditions may be more abundant, while those associated with slower currents may be less abundant. Conversely, during periods of reduced flow, just prior to becoming cutoff, species associated with

these conditions may congregate in the side channel while more swift water-oriented species may leave the side channel.

It is apparent, based upon chemofishing collections, that the side channel habitat sampled supports a large assemblage of species and biomass (926 lbs. per surface acre) under low flow conditions. Many of the species collected, particularly those collected in abundance, as well as others, are frequently associated with reduced current areas. Collections of fish in the side channels at Ste. Genevieve and Cape Girardeau during normal sampling periods also reflect this trend (Tables 6.2-6 and 6.2-7).

The chemofishing sampling, supported by the collection during normal conditions, indicates that the side channel areas in the open river provide important habitat for many fish species, particularly species associated with reduced current. Side channels apparently support a large diversity and density of fishes compared to other habitats in the open river stretch of the GREAT III study area.

6.2.3 ICHTHYOPLANKTON

Twenty-two identifiable ichthyoplankton taxa were collected during the GREAT III Ecological Characterization Study at the four sampling areas (Table 6.2-15). Collection periods were limited to four occasions at each area. Consequently, the collection periods were widely scattered throughout the study.

It has been well established that water temperature, river stage, and other physical factors influence the spawning of fishes and the subsequent collection of their larvae (Bagenal and Braum, 1971).

TAXONOMIC COMPOSITION AND RELATIVE ABUNDANCE OF ICHTHYOPLANKTON

Sampling at the Clarksville site resulted in the collection of 13 identifiable taxa. Highest densities were observed for *Dorosoma* spp. or *Alosa* spp., cyprinids, *Cyprinus carpio* or *Carassius auratus*,

Carpiodes spp. or Ictiobus spp., Stizostedion spp. and Aplodinotus grunniens (Table 6.2-16).

Twelve taxa were collected at the Winfield site during ichthyoplankton sampling. Dorosoma spp. or Alosa spp. dominated the collections numerically. Other abundant taxa at the Winfield site included cyprinidae, Morone spp., and Aplodinotus grunniens (Table 6.2-17).

Collections at Ste. Genevieve contained twelve species with Dorosoma spp. or Alosa spp., Carpiodes spp. or Ictiobus spp., and Aplodinotus grunniens comprising most of the catch (Table 6.2-18). Sampling at Cape Girardeau resulted in 16 taxa being collected. Dominant taxa in the Cape Girardeau samples were Dorosoma spp. or Alosa spp. and Aplodinotus grunniens (Table 6.2-19).

Taxa-specific densities were variable among sampling areas. Highest densities were recorded for Dorosoma spp. or Alosa spp. (probably all gizzard shad) at Winfield in the spring when densities reached 41.62 and 28.32 larvae/m^3 at the littoral habitats. All other densities recorded were below 3.0/m^3 with most below 1.0/m^3.

Abundant taxa at all sampling sites (in addition to Dorosoma spp. or Alosa spp.) were cyprinidae, Carpiodes spp. or Ictiobus spp., Stizostedion spp., and Aplodinotus grunniens. Density differences among these taxa varied among sample sites. Due to the differences between collection times at each site, it cannot be determined if the observed differences among the densities of specific taxa are due to spatial or temporal variations. However, the data indicated that reproduction of the collected taxa is occurring at or near the sites at which they were collected. The data did not indicate the period of temporal occurrence of peak abundance periods for specific taxa.

SEASONAL CHANGES IN ICHTHYOPLANKTON COMPOSITION AND ABUNDANCE

The data collected at the four sampling sites indicate that highest ichthyoplankton densities occurred during the spring and early summer. Collections made after late June resulted in low ichthyoplankton densities. Highest densities were recorded on June 10, 1981 at Winfield, with the majority of the larvae being Dorosoma spp. or Alosa spp. Highest densities of Aplodinotus grunniens larvae were collected on June 16, 1981 at Cape Girardeau, while highest Stizostedion spp. larval densities were recorded on April 30, 1981 at Clarksville. Other commonly collected larvae such as Carpiodes spp. or Ictiobus spp. were most abundant in May collections while Morone spp. densities were highest in early June.

The seasonal data collected indicate that the majority of spawning had ceased by early July 1981. Stizostedion spp. and Hiodon spp. larvae were most common in the April through mid May collection. Carpiodes spp. or Ictiobus spp. were most common in the May samples although larvae of this group were collected through late June. Morone spp. and Dorosoma spp. or Alosa spp. were collected from April through late June, with greatest densities recorded in early June. Aplodinotus grunniens larvae were most abundant in the mid to late June samples, although they were present in the April samples.

The seasonal progression of taxa collected in the ichthyoplankton samples reflects historically documented spawning periods (Smith 1979; Pflieger, 1975). Typically, species such as sauger and walleye (Stizostedion spp.) are early spring spawners while goldeye and mooneye (Hiodon spp.), white bass and yellow bass (Morone spp.), black and white crappie (Pomoxis spp.) and carpsucker and buffalo (Carpiodes spp. or Ictiobus spp.) are mid spring spawners. Taxa such as Dorosoma spp. or Alosa spp. and Lepomis spp. are typically late spring spawners, while freshwater drum are early summer spawners. Although limited in scope, the data collected during the GREAT III study reflected these historical spawning periods. However, the data did not indicate [illegible] larval

densities or peak spawning periods for the taxa collected. The highest densities recorded during the study period were lower for all taxa than peak densities recorded from other large river investigations (Hall, 1980; Gill, 1981). These results indicate that collections made during the GREAT III Ecological Characterization Study did not occur during days of peak icthyoplankton abundance.

ICHTHYOPLANKTON HABITAT ASSOCIATIONS

Ichthyoplankton densities for all taxa collected were typically highest at near shore locations (natural and revetted littoral habitats). Most taxa including *Carpiodes* spp. or *Ictiobus* spp., *Dorosoma* spp. or *Alosa* spp., freshwater drum, temperate basses, walleye or saugers, and crappies exhibited highest densities at littoral areas. Density differences between revetted and natural littoral areas were variable among sampling sites and periods with no consistent differences noted.

Although most abundant in littoral habitats, larvae of *Aplodinotus grunniens*, *Morone* spp., and *Dorosoma* spp. or *Alosa* spp. were common in the main channel collections. Densities in the main channel collection were typically lower than those in littoral areas. However, the main channel collection densities were frequently higher than those of the navigation pool or tailwater habitats.

The collection of higher densities of larvae at the near shore locations documented during this study is typical of riverine ichthyoplankton collections (Gallagher and Connor, 1980). Species such as gizzard shad, minnows (cyprinidae), carp, carpsucker, buffalo, as well as nest builders such as crappie and sunfish, typically spawn in shallow water and in reduced current areas (Smith, 1979; Pflieger, 1975). The associations of these species with shallow water areas for spawning may be directly related to the higher larval densities recorded from the littoral areas compared to other areas sampled, which were typically in deeper water. Other shallow water areas such as sloughs, river lakes,

and some side channels may also support high densities of larvae. However, samples were not taken in these areas. Studies by Hall (1980), Ragland (1974), Farabee (1979), Hynes (1970) and Bertrand and Dunn (1973) indicate that extrachannel areas such as side channels, sloughs, and other backwaters are important spawning areas for sunfishes, crappies, shad, buffalos, and many other species.

Species such as freshwater drum and white bass (the most abundant Morone spp. in the sampling area) are typically mid water spawners. The larvae of these species, although most abundant in littoral habitats, were also common in the main channel. Their open water spawning habits are a major factor in the wide distribution of their larvae.

Gizzard shad larvae (Dorosoma spp. or Alosa spp.), the other taxa which were commonly collected at the main channel habitat, commonly spawn in shallow slackwater habitats. These larvae, most abundant at littoral areas, are small, fragile larvae which are evidently more readily affected by river currents than are other species. This lack of mobility, along with their abundance, may be responsible for their common presence in main channel collections.

Sauger and walleye (Stizostedion spp.) characteristically spawn in shallow, swift water on firm substrates (Pflieger, 1975; Smith, 1979). This spawning affinity may be responsible for the abundance of Stizostedion spp. larvae along littoral areas, particularily revetted littoral areas. These areas generally provide firm substrates and swifter currents than natural littoral habitats in the GREAT III reach. Spawning may also occur in tailwater habitats.

The density and abundance of ichthyoplankton may vary annually on a species-specific basis. Gallagher and Connor (1980) indicate that certain spring spawning species (such as shads, carp, buffalos, temperate basses, centrarchids and percids) generally have more

successful spawning during high water years. Species which spawn in the summer, however, (certain minnow species, freshwater drum, river carpsucker, etc.) typically were most successful during low flow years. The 1981 GREAT III ichthyoplankton collections were made during a high flow year. Based upon the Gallagher and Conner (1980) observations, it would appear that spring spawners had a more successful spawning year than did the summer spawners. However, the data collected were not of sufficient magnitude to document this occurrence.

Table 6.2-1. Species of Fish Collected, GREAT III Reach

Petromyzontidae (Lampreys)	
Chestnut lamprey	Ichthyomyzon castaneus
Acipenseridae (Sturgeons)	
Shovelnose sturgeon	Scaphirhynchus platorynchus
Polyodontidae (Paddlefishes)	
Paddlefish*	Polyodon spathula
Lepisosteidae (Gars)	
Shortnose gar	Lepisosteus platostomus
Spotted gar	Lepisosteus oculatus
Longnose gar	Lepisosteus osseus
Amiidae (Bowfins)	
Bowfin	Amia calva
Anguillidae (Eels)	
American eel	Anguilla rostrata
Clupeidae (Herrings)	
Skipjack herring	Alosa chrysochloris
Gizzard shad	Dorosoma cepedianum
Threadfin shad	Dorosoma petenense
Hiodontidae (Mooneyes)	
Goldeye	Hiodon alosoides
Mooneye	Hiodon tergisus
Cyprinidae (Minnows)	
Common carp	Cyprinus carpio
Grass carp*	Ctenopharyngodon idella
Golden shiner	Notemigonus crysoleucas
Silver chub	Hybopsis storeriana
Speckled chub	Hybopsis aestivalis
Flathead chub	Hybopsis gracilis
Emerald shiner	Notropis atherinoides
Redfin shiner	Notropis umbratilis
River shiner	Notropis blennius
Steelcolor shiner	Notropis whipplei
Spotfin shiner	Notropis spilopterus
Red shiner	Notropis lutrensis
Sand shiner	Notropis stramineus
Mimic shiner	Notropis volucellus
Bullhead minnow	Pimephales vigilax
Bluntnose minnow	Pimephales notatus
Fathead minnow	Pimephales promelas
Central stoneroller	Campostoma anomalum

Table 6.2-1. Species of Fish Collected, GREAT III Reach (Continued, Page 2 of 2)

Catastomidae (Suckers)	
Bigmouth buffalo	Ictiobus cyprinellus
Black buffalo	Ictiobus niger
Smallmouth buffalo	Ictiobus bubalus
River carpsucker	Carpiodes carpio
Highfin carpsucker	Carpiodes velifer
Quillback	Carpiodes cyprinus
Golden redhorse	Moxostoma erythrurum
Shorthead redhorse	Moxostoma macrolepidotum
River redhorse	Moxostoma carinatum
Ictaluridae (Catfish)	
Black bullhead	Ictalurus melas
Brown bullhead	Ictalurus nebulosus
Yellow bullhead	Ictalurus natalis
Channel catfish	Ictalurus punctatus
Blue catfish	Ictalurus furcatus
Flathead catfish	Pylodictis olivaris
Poeciliidae (Livebearers)	
Mosquitofish	Gambusia affinis
Percichthyidae (Sea basses)	
White bass	Morone chrysops
Yellow bass	Morone mississippiensis
Striped bass†	Morone saxatilis
Centrarchidae (Sunfish)	
Smallmouth bass	Micropterus dolomieui
Largemouth bass	Micropterus salmoides
Warmouth	Lepomis gulosus
Green sunfish	Lepomis cyanellus
Redear sunfish	Lepomis microlophus
Orangespotted sunfish	Lepomis humilis
Bluegill	Lepomis macrochirus
Warmouth x Bluegill hybrid	Lepomis gulosus x L. macrochirus
Green sunfish x Bluegill hybrid	Lepomis cyanellus x L. macrochirus
White crappie	Pomoxis annularis
Black crappie	Pomoxis nigromaculatus
Percidae (Perches)	
Walleye	Stizostedion vitreum
Sauger	Stizostedion canadense
Western sand darter	Ammocrypta clara
Sciaenidae (Drums)	
Freshwater drum	Aplodinotus grunniens

* Collected during electrofishing study only.
† Collected by IDOC personnel from the stone dike habitat while assisting with side channel electrofishing study.

Source: ESE, 1982.

Table 6.2-2. Classification of Fish Species Collected from the Mississippi River during the Great III Ecological Characterization Study*

Sport	Commercial	Forage	Predatory Nonsport/ Commercial	Omnivorous Nonsport/ Commercial
Paddlefish**	carp†	Gizzard shad	American eel	Shorthead redhorse
Shovelnose sturgeon†	Grass carp**	Threadfin shad	Chestnut lamprey	River redhorse
Channel catfish†	Quillback	Golder shiner	Skipjack herring	Golden redhorse
Blue catfish†	River carpsucker	River shiner	Mooneye	Orangespotted sunfish
Flathead catfish†	Highfin carpsucker	Emerald shiner	Goldeye	Western sand darter
Black bullhead	Bigmouth buffalo	Sand shiner	Shortnose gar	
Yellow bullhead	Smallmouth buffalo	Spotfin shiner	Longnose gar	
Largemouth bass	Black buffalo	Mimic shiner	Spotted gar	
Smallmouth bass	Freshwater drum†	Steelcolor shiner	Bowfin	
Green sunfish		Red shiner		
Redear sunfish		Redfin shiner		
Bluegill		Fathead minnow		
Warmouth		Bullhead minnow		
White crappie		Bluntnose minnow		
Black crappie		Central stoneroller		
Yellow bass		Flathead chub		
White bass		Silver chub		
Walleye		Speckled chub		
Sauger		Mosquitofish		

* Classification based upon utilization and life history of fish species within the Great III study reach.
† Species frequently considered important as both sport and commercial fishes.
** Collected only during the side channel rotenone study.

Source: [illegible], 1982.

Table 6.2-3. Fishes Collected* at Each Sample Area, All Sampling Dates Combined, GREAT III Reach

	Clarksville		Winfield		Ste. Genevieve		Cape Girardeau		Total	
	#	%	#	%	#	%	#	%	#	%
Gizzard shad	1735	28.4	2052	24.1	3204	64.8	1323	44.3	8314	36.8
Common carp	1003	16.4	1066	12.5	521	10.5	320	10.7	2910	12.9
Emerald shiner	543	8.9	994	11.6	310	6.3	490	16.4	2337	10.4
Freshwater drum	610	10.0	506	5.9	122	2.5	170	5.7	1408	6.2
River shiner	252	4.1	515	6.0	123	2.5	42	1.4	932	4.1
Channel catfish	263	4.3	357	4.2	75	1.5	59	2.0	754	3.3
Bluegill	170	2.8	533	6.2	18	0.4	21	0.7	742	3.3
Shortnose gar	212	3.5	339	4.0	58	1.2	115	3.8	724	3.2
Black bullhead	94	1.5	477	5.6	2	0.0	0	—	573	2.5
Black crappie	79	1.3	454	5.3	6	0.1	5	0.2	544	2.4
White bass	140	2.3	202	2.4	80	1.6	41	1.6	463	2.1
Smallmouth buffalo	135	2.2	209	2.4	12	0.2	18	0.6	374	1.6
Goldeye	24	0.4	20	0.2	103	2.1	145	4.8	292	1.3
River carpsucker	116	1.9	96	1.2	60	1.2	55	1.8	327	1.4
Flathead catfish	73	1.2	79	0.9	68	1.4	43	1.4	263	1.2
White crappie	36	0.6	119	1.4	18	0.4	10	0.3	183	0.8
Bigmouth buffalo	52	0.9	71	0.8	7	0.1	12	0.4	142	0.6
Largemouth bass	15	0.2	113	1.3	2	0.0	3	0.1	133	0.6
Longnose gar	34	0.6	38	0.4	6	0.1	9	0.3	87	0.4
Sauger	37	0.6	28	0.3	7	0.1	5	0.2	77	0.3
Bullhead minnow	56	0.9	30	0.4	0	—	0	—	86	0.4
Mooneye	22	0.4	17	0.2	19	0.4	6	0.2	64	0.3
Shorthead redhorse	34	0.6	14	0.2	13	0.3	0	—	61	0.3
Sand shiner	48	0.8	8	0.1	0	—	1	0.0	57	0.2
Bowfin	17	0.3	35	0.4	0	—	3	0.1	55	0.2
Quillback	39	0.6	14	0.2	2	0.0	0	—	55	0.2
Shovelnose sturgeon	28	0.5	14	0.2	3	0.0	6	0.2	51	0.2
Speckled chub	8	0.1	10	0.1	32	0.6	0	—	50	0.2
Buffaloes (*Ictiobus* spp.)	1	0.0	0	—	3	0.1	45	1.5	49	0.2
Mosquitofish	46	0.8	0	—	1	0.0	0	—	47	0.2
Silver chub	19	0.3	6	0.1	19	0.4	2	0.1	46	0.2
Carpsuckers (*Carpiodes* spp.)	40	0.6	9	0.0	0	—	0	—	49	0.2
Green sunfish	30	0.5	4	0.0	0	—	0	—	34	0.1
American eel	15	0.2	5	0.1	4	0.1	3	0.1	27	0.1
Carpiodes or *Ictiobus*	10	0.2	2	0.0	4	0.1	1	0.0	17	0.1
Spotted gar	4	0.1	21	0.2	0	—	1	0.0	26	0.1
Orangespotted sunfish	11	0.2	7	0.1	0	—	4	0.0	22	0.1
Skipjack herring	3	0.0	2	0.0	12	0.2	5	0.2	22	0.1

Table 6.2-3. Fishes Collected* at Each Sample Area, All Sampling Dates Combined, GREAT III Reach (Continued, Page 2 of 2)

	Clarksville #	Clarksville %	Winfield #	Winfield %	Ste. Genevieve #	Ste. Genevieve %	Cape Girardeau #	Cape Girardeau %	Total #	Total %
Warmouth	1	0.0	20	0.2	0	—	0	—	21	0.1
Threadfin shad	0	—	1	0.0	15	0.3	4	0.1	20	0.1
Yellow bullhead	4	0.1	15	0.2	0	—	0	—	19	0.1
Shiners (Notropis spp.)	16	0.3	1	0.0	0	—	0	—	17	0.1
Red shiner	1	0.0	11	0.1	0	—	2	0.1	14	0.1
Blue catfish	1	0.0	0	—	7	0.1	5	0.2	13	0.1
Chestnut lamprey	0	—	0	—	8	0.2	3	0.1	11	0.0
Steelcolor shiner	7	0.1	1	0.0	0	—	3	0.1	11	0.0
Fathead minnow	1	0.0	0	—	0	—	0	—	1	0.0
River redhorse	1	0.0	0	—	0	—	1	0.0	2	0.0
Spotfin shiner	3	0.0	1	0.0	0	—	1	0.0	5	0.0
Bluntnose minnow	2	0.0	2	0.0	0	—	0	—	4	0.0
Golden redhorse	3	0.0	1	0.0	0	—	0	—	4	0.0
Sunfishes (Lepomis spp.)	1	0.0	0	—	0	—	3	0.1	4	0.0
Yellow bass	0	—	1	0.0	1	0.0	1	0.0	3	0.0
Golden shiner	0	—	3	0.0	0	—	0	—	3	0.0
Mimic shiner	2	0.0	0	—	0	—	1	0.0	3	0.0
Smallmouth bass	2	0.0	1	0.0	0	—	0	—	3	0.0
Redfin shiner	2	0.0	0	—	0	—	0	—	2	0.0
Flathead chub	0	—	0	—	2	0.0	0	—	2	0.0
Highfin carpsucker	2	0.0	0	—	0	—	0	—	2	0.0
Brown bullhead	0	—	2	0.0	0	—	0	—	2	0.0
Walleye	1	0.0	1	0.0	0	—	0	—	2	0.0
Western sand darter	1	0.0	1	0.0	0	—	0	—	2	0.0
Warmouth X bluegill (hybrid)	0	—	2	0.0	0	—	0	—	2	0.0
Green sunfish X bluegill (hybrid)	2	0.0	0	—	0	—	0	—	2	0.0
Central stoneroller	1	0.0	0	—	0	—	0	—	1	0.0
Black buffalo	0	—	1	0.0	0	—	0	—	1	0.0
Ictaluridae spp.	0	—	1	0.0	0	—	0	—	1	0.0
Redear sunfish	0	—	0	—	1	0.0	0	—	1	0.0
TOTAL	6,108		8,532		4,947		2,[illegible]		[illegible]	
Number of Taxa	38		35		37		40		[illegible]	
Shannon-Weaver Index	3.65		3.68		2.19		2.[illegible]			
Evenness Index	2.07		2.11		1.40		1.75			

* Excluding chemofishing data.

Source: ESE, 1982.

Table 6.2-4. Fishes Collected* by Each Sampling Method, All Sampling Dates and Areas Combined, GREAT III Reach

	Electro-fishing	Frame Netting	Gill Netting	Hoop Netting	Trammel Netting	Seining	Trawling	Total
Gizzard shad	5,363	517	1,168	73	8	1,179	6	8,314
Common carp	2,681	61	146	13	6	1	2	2,910
Emerald shiner	92	0	0	0	0	2,245	0	2,337
Freshwater drum	946	113	30	205	3	108	3	1,408
River shiner	23	0	0	0	0	908	1	932
Channel catfish	460	0	16	24	2	[illegible]	29	754
Bluegill	418	278	8	24	0	14	0	742
Shortnose gar	265	195	217	40	3	4	0	724
Black bullhead	126	63	379	5	0	0	0	573
Black crappie	142	347	16	37	1	1	0	544
White bass	307	85	15	22	0	34	0	463
Smallmouth buffalo	231	68	34	15	24	2	0	374
River carpsucker	184	49	28	14	10	42	0	327
Goldeye	207	3	80	0	0	2	0	292
Flathead catfish	84	3	0	173	0	3	0	263
White crappie	87	74	6	16	0	0	0	183
Bigmouth buffalo	78	20	35	1	7	0	1	142
Largemouth bass	75	27	30	1	0	0	0	133
Longnose gar	48	5	31	0	3	0	0	87
Bullhead minnow	23	0	0	0	0	63	0	86
Sauger	43	7	23	3	0	1	0	77
Mooneye	49	0	11	0	0	3	1	64
Shorthead redhorse	39	2	6	11	3	0	0	61
Sand shiner	0	0	0	0	0	57	0	57
Bowfin	7	33	14	1	0	0	0	58
Quillback	41	5	4	1	3	0	1	55
Shovelnose sturgeon	2	0	37	2	1	0	9	51
Speckled chub	0	0	0	0	0	32	18	50
Carpsuckers (Carpiodes spp.)	38	0	2	0	0	9	0	49
Buffalos (Ictiobus spp.)	1	0	0	0	0	48	0	49
Mosquitofish	1	0	0	0	0	46	0	47
Silver chub	20	0	0	0	0	26	0	46
Green sunfish	22	9	2	1	0	0	0	34
American eel	19	4	0	4	0	0	0	27
Spotted gar	1	17	7	0	0	1	0	26
Orangespotted sunfish	17	0	2	0	0	3	0	22
Skipjack herring	11	1	3	2	1	3	0	21
Warmouth	13	5	3	0	0	0	0	21
Threadfin shad	3	1	0	0	0	16	0	20
Yellow bullhead	5	2	11	1	0	0	0	19
Shiners (Notropis spp.)	0	0	0	0	0	17	0	17
Carpsuckers or Buffalos (Carpiodes or Ictiobus)	2	0	0	0	0	15	0	17
Red shiner	9	2	0	0	0	3	0	14
Blue catfish	7	0	1	5	0	0	0	13
Chestnut lamprey	11	0	0	0	0	0	0	11
Steelcolor shiner	0	0	0	0	0	11	0	11
Spotfin shiner	2	0	0	0	0	3	0	5
Bluntnose minnow	2	0	0	0	0	2	0	4
Golden redhorse	4	0	0	0	0	0	0	4
Sunfish (Lepomis spp.)	1	0	0	0	0	3	0	4
Golden shiner	3	0	0	0	0	0	0	3
Mimic shiner	0	0	0	0	0	3	0	3
Yellow bass	3	0	0	0	0	0	0	3
Smallmouth bass	3	0	0	0	0	0	0	3
Flathead chub	0	0	0	0	0	2	0	2
Redfin shiner	0	0	0	0	0	2	0	2
Highfin carpsucker	0	1	0	0	1	0	0	2
River redhorse	1	0	0	1	0	0	0	2
Brown bullhead	0	1	1	0	0	0	0	2
Warmouth x bluegill hybrid	2	0	0	0	0	0	0	2
Green sunfish x bluegill hybrid	0	2	0	0	0	0	0	2
Western sand darter	0	0	0	0	0	1	1	2
Walleye	1	0	0	1	0	0	0	2
Central stoneroller	0	0	0	0	0	1	0	1
Fathead minnow	0	0	0	0	0	1	0	1
Black buffalo	0	1	0	0	0	0	0	1
Freshwater catfish (Ictaluridae)	0	0	0	1	0	0	0	1
Redear sunfish	1	0	0	0	0	0	0	1
Total	12,224	2,001	2,366	697	76	5,138	72	22,574

* Excluding chemofishing data.

Source: ESE, 1982.

Table 6.2-5. Fishes Collected* at Each Habitat at the Clarksville Sampling Area, All Sampling Dates Combined, GREAT III Reach

	Tail-waters (1)	Navi-gation Pool (2)	Rivers, Lakes, & Ponds (3)	Slough (4)	Down-stream End of Island (5)	Dike Field (6)	Main Channel (7)	Main Channel Border Inside Bend (8)	Main Channel Border Outside Bend (9)	Main Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Totals
Chestnut lamprey														0
Shovelnose sturgeon	25				1					2				28
Spotted gar			3	1										4
Longnose gar	8	11			7	3		1		1		1	2	34
Shortnose gar	11	32	85	31	32	5		2	2	6	3	3		212
Bowfin			13	2	2									17
American eel	2	5			3			2	2				1	15
Skipjack herring		2										1		3
Gizzard shad	126	582	335	170	140	38		90	15	38	43	118	40	1,735
Threadfin shad														0
Goldeye	1	9			10				1	1	2			24
Mooneye	2				4	2			9	5				22
Central stoneroller												1		1
Common carp	74	99	240	7	34	74		86	36	49	97	73	134	1,003
Speckled chub							8							8
Flathead chub														0
Silver chub								3		2		14		19
Golden shiner														0
Shiners (Notropis spp.)												16		16
Emerald shiner	2	4		28	6	6		7		1	1	488		543
River shiner											1	251		252
Red shiner												1		1
Spotfin shiner												3		3
Sand shiner												48		48
Redfin shiner												2		2
Mimic shiner												2		2
Steelcolor shiner												7		7
Bluntnose minnow												2		2
Fathead minnow												1		1
Bullhead minnow					2							54		56
Carpsuckers (Carpiodes spp.)		6		15	1							8		30

Table 6.2-5. Fishes Collected[a] at Each Habitat at the Clarksville Sampling Area, All Sampling Dates Combined, GREAT III Reach (Continued, Page 2 of 3)

	Tail-waters (1)	Navi-gation Pool (2)	Rivers, Lakes, & Ponds (3)	Slough (4)	Down-stream End of Island (5)	Dike Field (6)	Main Channel (7)	Main Channel Border Inside Bend (8)	Main Channel Border Outside Bend (9)	Main Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Totals
River carpsucker	21	22		8	17	10		6	1	6	5	15	5	116
Quillback	4	7		5		5	1	1	1	6	3	5	1	39
Highfin carpsucker					1					1				2
Buffaloes (Ictiobus spp.)					1									1
Smallmouth buffalo	15	53	7	8	5	20		6	7	5	3	2	4	135
Bigmouth buffalo	1	7	37	3	2								2	52
Black buffalo														0
River redhorse											1	0		1
Golden redhorse										3				3
Shorthead redhorse	1	2			3	2		8	3	11	1	2	1	34
Carpsuckers or buffalos											0	10		10
Ictaluridae-freshwater catfish														0
Blue catfish		1												1
Black bullhead	1		76	14	1					2				94
Yellow bullhead			4											4
Brown bullhead														0
Channel catfish	8	24			9	10	17	26	16	23	6	88	36	263
Flathead catfish	3	2			5	15		16	14	8	1	2	7	73
Mosquitofish			1									45		46
White bass	9	20		3	16	12		7	25	16	6	11	15	140
Yellow bass														0
Sunfish (Lepomis spp.)				1										1
Green sunfish	1	9	11	4		1				1		2	1	30
Warmouth				1										1
Orangespotted sunfish		2	2	3		1						3		11
Bluegill	1	20	25	94	5	12			1	1		6	5	170
Redear sunfish														0
Warmouth X bluegill (hybrid)														0

Table 6.2-5 Fishes Collected[a] at Each Habitat at the Clarksville Sampling Area, All Sampling Dates Combined, GREAT III Reach (Continued, Page 3 of 3)

	Tailwaters (1)	Navigation Pool (2)	Rivers, Lakes, & Ponds (3)	Slough (4)	Downstream End of Island (5)	Dike Field (6)	Main Channel (7)	Main Channel Border Inside Bend (8)	Main Channel Border Outside Bend (9)	Main Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Totals
Green sunfish X bluegill (hybrid)			2											2
Smallmouth bass	1												1	2
Largemouth bass		7	1	3	1	2							1	15
White crappie	8	23	1			2							2	36
Black crappie	1	42	6	7	8	7			1	5		2		79
Western sand darter							1							1
Sauger		15			12	5		2	1			1	1	37
Walleye								1						1
Freshwater drum	[illegible]	90	12		22	70	2	55	63	67	13	94	85	610
Total	[illegible]	[illegible]	861	408	350	302	29	319	198	260	196	1382	344	6108
# of Taxa	[illegible]	[illegible]	18	20	27	21	5	17	17	23	16	36	19	58
Shannon-Weaver Index	[illegible]	[illegible]	2.45	2.09	3.25	3.27	1.52	2.76	2.93	3.29	2.37	3.12	2.51	3.65
Simpson's Index	[illegible]	1.91	1.95	2.07	2.27	2.47	2.17	2.24	2.38	2.42	1.97	2.00	1.96	2.07

[a] Excluding electrofishing data.

Source: NBS, 1982.

Table 6.2-6. Fishes Collected[a] at Each Habitat at the Winfield Sampling Area,[b] All Sampling Dates Combined, GREAT III Reach

	Tail-waters (1)	Navi-gation Pool (2)	Rivers, Lakes, & Ponds (3)	Slough (4)	Down-stream End of Island (5)	Dike Field (6)	Main Channel (7)	Main Channel Border Inside Bend (8)	Main Channel Border Outside Bend (9)	Main Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Totals
Chestnut lamprey														0
Shovelnose sturgeon	1					8	4				1			14
Spotted gar		2	17	1								1		21
Longnose gar	8	3	1	4	8	1			7	3	2		1	38
Shortnose gar	14	65	47	76	32	13		11	36	34	8	2	1	339
Bowfin			34	1										35
American eel		3											2	5
Skipjack herring					1			1						2
Gizzard shad	619	212	288	274	180	90	1	16	184	106	7	66	[illegible]	[illegible]
Threadfin shad		1												1
Goldeye	3	11		1	1	1			2	1				20
Mooneye		6			2						6	3		17
Central stoneroller														0
Common carp	60	71	128	82	53	103		76	33	86	72	128	174	1066
Speckled chub							10							10
Flathead chub														0
Silver chub					1							4	1	6
Golden shiner			3											3
Shiners (Notropis spp.)												1		1
Emerald shiner		2		1	8	2					1	979	1	994
River shiner		2			9						1	502		515
Red shiner		3		4							1	3		11
Spotfin shiner					1									1
Sand shiner												8		8
Redfin shiner														0
Mimic shiner														0
Steelcolor shiner												1		1
Bluntnose minnow					1	1								2
Fathead minnow														0
Bullhead minnow		13		2	3							11	1	30
Carpsuckers (Carpiodes spp.)					2	5						2		9

Table 6.2-6. Fishes Collected at Each Habitat at the Winfield Sampling Area, All Sampling Dates Combined, GREAT III Reach (Continued, Page 2 of 3)

	Tailwaters (1)	Navigation Pool (2)	Rivers, Lakes, & Ponds (3)	Slough (4)	Downstream End of Island (5)	Dike Field (6)	Main Channel (7)	Main Channel Border Inside Bend (8)	Main Channel Border Outside Bend (9)	Main Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Totals
River carpsucker	2	21	7	25	12	3		4	3	4		10	3	96
Quillback	1		1	4	2			2				3		98
Highfin carpsucker														0
Buffalo (Ictiobus spp.)														0
[illegible]	6	42	10	66	10	10		10	12	13	7	7	16	209
[illegible]	1	51	23	14		8			9		1	3		70
[illegible]				1										1
[illegible]														0
[illegible]												1		1
[illegible]	4	2			1	2		1	1	1	1	2		14
[illegible]												2		2
Carpsucker or buffaloes									1					1
[illegible]														0
Blue catfish		1	467	7		1		1						477
Black bullhead		1	12	1					1					15
Yellow bullhead			2											2
Brown bullhead	16	26	3	19	7	18	7	13	9	31	26	122	62	387
Channel catfish	2	1			1	10		9	17	16	1	6	16	79
Flathead catfish														0
[illegible]	[illegible]	23	63	16	10	4		11	8	9	1	20	11	202
White bass			1											1
Yellow bass														0
Sunfish (Lepomis spp.)			3		1									4
Green sunfish			20											20
[illegible]			6	1										7
[illegible] sunfish	2	31	463	19	3	9			1	1	2	2		533
Bluegill														0
[illegible] sunfish			2											2
[illegible] (hybrid)														

Table 6.2-6. Fishes Collected* at Each Habitat at the Winfield Sampling Area, All Sampling Dates Combined, GREAT III Reach (Continued, Page 3 of 3)

	Tail-waters (1)	Navi-gation Pool (2)	Rivers, Lakes, & Ponds (3)	Slough (4)	Down-stream End of Island (5)	Dike Field (6)	Main Channel (7)	Main Channel Border Inside Bend (8)	Main Channel Border Outside Bend (9)	Main Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Totals
Green sunfish X bluegill (hybrid)														[illegible]
Smallmouth bass	1													1
Largemouth bass	1	15	90	3	1						1	2		113
White crappie	18	8	64	12	5	3		1	2	3	2	1		119
Black crappie	5	15	372	24	2	10		5		14	1	5	1	454
Western sand darter												1		1
Sauger	11				8	2			1	3		2	1	28
Walleye			1											1
Freshwater drum	31	60	11	56	17	29	1	60	42	47	13	48	94	[illegible]
TOTAL	850	651	2119	714	382	333	24	221	369	372	157	1927	413	8532
# of Taxa	21	27	27	25	20	22	5	15	18	16	21	32	15	55
Shannon-Weaver Index	1.69	3.37	3.06	3.03	2.88	3.03	1.90	2.72	2.52	2.08	2.73	2.15	2.27	3.60
Evenness Index	1.28	2.35	2.14	2.17	1.99	2.26	2.72	2.31	2.01	2.39	2.06	1.43	2.08	2.11

* Excluding chemofishing data.

Source: NEE, 1982.

Table [illegible]. [illegible] Collected[illegible] at Each Habitat at the Ste. Genevieve Sampling Area, All Sampling Dates Combined, [illegible]

	Main Channel (7)	Channel Border Inside (8)	Channel Border Outside (9)	Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Pile Dike (14)	Stone Dike (15)	Mouth of Trib. (16)	Totals
[illegible]									2		8
[illegible]											3
[illegible]											0
[illegible]		1			3		1	1			6
[illegible]		2	2	5	24	5	4		5	11	38
[illegible]			2							2	
[illegible]		2	2	1	2				1		
[illegible]	2	24	284	673	59	837	846	3			
[illegible]						13	1				
[illegible]		2		16	1	5	55	15	7		
[illegible]				2			14	2	1		
[illegible]		2	1	56	36	22	121	4	234		
[illegible]						38					
[illegible]						2					
[illegible]					2	17					
[illegible]						307	1		2		
[illegible]					1	122					
[illegible]			1	1							

Table 6.2-7. Fishes Collected* at Each Habitat at the Ste. Genevieve Sampling Site, All Sampling Dates Combined, [illegible] III Reach (Continued, Page 2 of 3)

	Main Channel (7)	Main Channel Border Inside (8)	Main Channel Border Outside (9)	Main Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Pile Dike (14)	Stone Dike (15)	Mouth of Trib. (16)	Totals
River carpsucker		2		4	7	29	3		5	10	[illegible]
Quillback			1		1						2
Highfin carpsucker											0
Buffalos (Ictiobus spp.)						3					[illegible]
Smallmouth buffalo			1	1	2	2	2	1	2	1	[illegible]
Bigmouth buffalo	1	1	1	1	3						[illegible]
Black buffalo											0
River redhorse											0
Golden redhorse											0
Shorthead redhorse		6	2	1	2		2				13
Carpsuckers or buffalos					2	2					4
Ictaluridae—freshwater catfish											0
Blue catfish		3	1						3		7
Black bullhead				1						1	2
Yellow bullhead											0
Brown bullhead											0
Channel catfish	5	1		4	2	54			9		75
Flathead catfish		14	7	31	1		4		7	4	[illegible]
Mosquitofish						1					[illegible]
White bass			1	8	1	14	4		15	37	80
Yellow bass										1	1
Sunfish (Lepomis spp.)											0
Green sunfish											0
Warmouth											0
Orangespotted sunfish											0
Bluegill				1	1					16	18
Redear sunfish									1		1
Warmouth X bluegill											0

Table 6.3-7. Fishes Collected* at Each Habitat at the Ste. Genevieve Sampling Area, All Sampling Dates Combined, GREAT III Reach (Continued, Page 3 of 3)

	Main Channel (7)	Main Channel Border Inside (8)	Main Channel Border Outside (9)	Main Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Pile Dike (14)	Stone Dike (15)	Mouth of Trib. (16)	Totals
Smallmouth bass											0
Largemouth bass							1			1	2
White crappie					3				6	9	[illegible]
Black crappie					1				1		[illegible]
Western sand darter											[illegible]
Sauger		1			4		1		1		[illegible]
Walleye											0
Freshwater drum		12	6	21	6	12	19		17	29	122
[illegible]	8	74	311	829	165	1481	1081	26	414	558	[illegible]
[illegible]	3	15	13	18	23	19	18	6	19	18	[illegible]
[illegible] Index	1.25	2.92	0.68	1.20	2.95	2.05	1.21	1.82	2.18	1.83	[illegible]
[illegible] Index	2.62	2.48	0.61	0.96	2.17	1.60	0.96	2.33	1.70	1.46	1.40

* [illegible]

Source: [illegible], 1982.

Table 6.2-8. Fishes Collected[a] at Each Habitat at the Cape Girardeau Sampling Area, All Sampling Dates Combined, GREAT III Reach

	Main Channel (7)	Main Channel Border Inside (8)	Main Channel Border Outside (9)	Main Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Pile Dike (14)	Stone Dike (15)	Mouth of Trib. (16)	Totals
Chestnut lamprey				2					1		[illegible]
Shovelnose sturgeon		1		5							[illegible]
Spotted gar					1						[illegible]
Longnose gar			1	1	3	1	1		1	1	9
Shortnose gar		1	6	3	49	6	4	10	14	22	[illegible]
Bowfin		1			1	1					[illegible]
American eel							2		1		[illegible]
Skipjack herring		1	1	1		2					[illegible]
Gizzard shad		48	16	83	433	357	62	66	119	190	[illegible]
Threadfin shad						3			1		[illegible]
Goldeye		67	13	31	1	18	12	2	1		[illegible]
Mooneye		1	1	2		1		1			6
Central stoneroller											0
Common carp		9	19	13	27	13	32	9	[illegible]		[illegible]
Speckled chub											0
Flathead chub											0
Silver chub						2					2
Golden shiner											0
Shiners (Notropis spp.)											0
Emerald shiner				1	1	484			4		490
River shiner						42					42
Red shiner						1	1				2
Spotfin shiner							1				1
Sand shiner						1					1
Redfin shiner											0
Mimic shiner						1					1
Steelcolor shiner						3					3
Bluntnose minnow											0
Fathead minnow											0
Bullhead minnow											0
Carpsuckers (Carpiodes spp.)											0

Table 6.2-8. Fishes Collected* at Each Habitat at the Cape Girardeau Sampling Area, All Sampling Dates Combined, GREAT III Reach (Continued, Page 2 of 3)

	Main Channel (7)	Main Channel Border Inside (8)	Main Channel Border Outside (9)	Main Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Pile Dike (14)	Stone Dike (15)	Mouth of Trib. (16)	Totals
River carpsucker		2	2	6	[illegible]	[illegible]	[illegible]	8	9	4	55
Quillback											0
[illegible]											0
[illegible]						45					45
[illegible]			2	3	2	3		3	2	3	18
[illegible]				1	2			2		7	12
[illegible]											0
[illegible]			1								[illegible]
[illegible]											0
[illegible]											0
[illegible]						1					1
[illegible]											[illegible]
[illegible]			1	3			1				5
[illegible]											0
[illegible]											[illegible]
[illegible]											0
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		17	6	59
[illegible]		17	5	3	5	1	9		2	1	43
[illegible]											[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		8	3	[illegible]
[illegible]						1					1
[illegible]						3					3
[illegible]											[illegible]
[illegible]											0
[illegible]										4	[illegible]
[illegible]					4	6		1	3	7	21
[illegible]											0
[illegible]											0

Table 6.2-8. Fishes Collected* at Each Habitat at the Cape Girardeau Sampling Area, All Sampling Gears Combined, GREAT III Reach (Continued, Page 3 of 3)

	Main Channel (7)	Main Channel Border Inside (8)	Main Channel Border Outside (9)	Main Channel Border Straight (10)	Side Channel (11)	Natural Littoral (12)	Revetted Littoral (13)	Pile Dike (14)	Stone Dike (15)	Mouth of Trib. (16)	Totals
Green sunfish X bluegill (hybrid)											0
Smallmouth bass											0
Largemouth bass					3						3
White crappie				1	2		1		2	4	10
Black crappie									3	2	5
Western sand darter											0
Sauger				2		1			1	1	5
Walleye											0
Freshwater drum		4	11	12	10	31	38	7	50	7	[illegible]
TOTAL	0	154	88	174	573	1070	178	89	405	263	[illegible]
# of Taxa	0	12	15	19	18	28	13	10	18	16	40
Shannon-Weaver Index	0.00	2.11	3.01	2.61	1.49	2.22	2.64	2.27	2.33	2.15	[illegible]
Evenness Index	0.00	1.96	2.56	2.04	1.19	1.53	2.24	2.27	1.86	1.78	1.75

* Excluding chemofishing data.

Source: EBE, 1982.

Table 6.2-9. Summary of Fish Diversity Data (Shannon-Weaver Index and Evenness Index††) by Habitat, GREAT III Reach

Habitat	Composite Diversity*				Average Diversity†		
	Clarksville	Winfield	Ste. Genevieve	Cape Girardeau	Pooled River	Open River	Overall
Tailwater	3.02 (2.19)	1.69 (1.28)	**	**	2.35 (1.74)	**	2.35 (1.74)
Navigation Pool	2.70 (1.91)	3.37 (2.35)	**	**	3.03 (2.13)	**	3.03 (2.13)
River Lake	2.45 (1.95)	3.06 (2.14)	**	**	2.75 (2.04)	**	2.75 (2.04)
Slough	2.69 (2.07)	3.03 (2.17)	**	**	2.86 (2.12)	**	2.86 (2.12)
Downstream End-of-Island	3.25 (2.27)	2.88 (1.99)	**	**	3.07 (2.13)	**	3.07 (2.13)
Dike Field	3.27 (2.47)	3.03 (2.26)	2.18 (1.70)	2.33 (1.86)	3.15 (2.36)	2.26 (1.78)	2.71 (2.07)
Main Channel	1.52 (2.17)	1.90 (2.72)	1.25 (2.62)	0.00 (0.00)	1.71 (2.44)	0.63 (1.31)	1.17 (1.88)
Main Channel Border—Inside Bend	2.76 (2.24)	2.72 (2.31)	2.92 (2.48)	2.11 (1.96)	2.74 (2.28)	2.51 (2.22)	2.63 (2.24)
Main Channel Border—Outside Bend	2.93 (2.38)	2.52 (2.01)	0.68 (0.61)	3.01 (2.56)	2.73 (2.20)	1.85 (1.58)	2.29 (1.89)
Main Channel Border—Straight	3.29 (2.42)	2.88 (2.39)	1.20 (0.96)	2.61 (2.04)	3.09 (2.40)	1.91 ([illegible])	2.50 (1.95)
Side Channel	2.37 (1.97)	2.72 (2.06)	2.95 (2.17)	1.49 (1.19)	2.55 (2.02)	2.37 ([illegible])	2.41 (1.85)
Natural Littoral	3.12 (2.00)	2.15 (1.43)	2.05 (1.60)	2.22 (1.53)	2.64 (1.72)	2.14 (1.56)	2.39 (1.64)
Revetted Littoral	2.51 (1.96)	2.37 (2.02)	1.21 (1.21)	2.64 (2.24)	2.44 (1.99)	1.93 (1.72)	2.19 (1.86)
Pile Dike	**	**	1.82 (2.33)	2.27 (2.27)	**	2.05 (2.30)	2.05 (2.30)
Mouth of Tributary	**	**	1.83 (1.46)	2.15 (1.78)	**	1.99 (1.62)	1.99 (1.62)
Mean Diversity (Evenness)	2.98 (2.15)	2.64 (2.09)	1.81 (1.71)	2.08 (1.94)	2.70 (2.12)	1.96 (1.73)	2.43 (1.96)

* Composite Diversity—Calculated on total data for four seasons (excluding chemofishing data).
† Average Diversity—Mathematical Average (excluding chemofishing data).
** Habitat not sampled.
†† Evenness Index in parentheses.

Source: NUS, 1982.

Table 6.2-10. Summary of Fish Catch-Per-Unit-Effort Data, GREAT III Reach

Habitat	Average CPE*													
	Pooled River							Open River						
	EF	TN	GN	HN	FN	TR	S	EF	TN	GN	HN	FN	TR	S
Tailwater	63.5	0.9	86.5	—†	—	—	—	—	—	—	—	—	—	—
Navigation Pool	44.1	—	44.3	—	24.5	—	—	—	—	—	—	—	—	—
River Lake	84.6	—	131.3	—	35.9	—	—	—	—	—	—	—	—	—
Slough	86.0	—	59.3	—	23.9	—	—	—	—	—	—	—	—	—
Downstream-End-of-Island	17.9	—	33.7	—	7.3	—	—	—	—	—	—	—	—	—
Dike Field	29.7	1.8	4.7	1.1	—	—	—	95.7	0.5	6.0	0.7	—	—	—
Main Channel	—	—	—	—	—	1.2	—	—	—	—	—	—	0.9	—
Main Channel Border-Inside Bend	33.6	0.2	0.5	0.9	—	—	—	10.3	0.2	31.0	0.8	—	—	—
Main Channel Border-Outside Bend	38.8	0.0	13.5	1.0	—	—	—	25.0	0.1	0.5	0.3	—	—	—
Main Channel Border-Straight	32.3	0.9	2.0	1.5	—	—	—	50.1	0.1	6.0	1.4	—	—	—
Side Channel	25.7	0.4	1.3	—	—	—	—	55.3	1.3	29.0	—	—	—	—
Natural Littoral	29.1	—	—	—	—	—	260.7	19.5	—	—	—	—	—	170.3
Revetted Littoral	47.4	—	—	—	—	—	—	63.7	—	—	—	—	—	—
Pile Dike	—	—	—	—	—	—	—	21.0	0.7	10.0	—	—	—	—
Mouth of Tributary	—	—	—	—	—	—	—	48.0	—	—	6.1	—	—	—
Mean CPE	44.4	0.7	37.7	2.23	22.9	1.2	260.7	43.2	0.5	13.7	1.7	—	0.9	170.3

* CPE = catch per unit effort.
† Method not used or habitat not sampled.

EF—Electrofishing; GN—Gill net; FN—Frame net; S—Seine; TN—Trammel net; HN—Hoop net; and TR—Trawl.

EF (per 30 min); FN, GN and HN (per net night); TR and TN (per 10 min); and S (per 1 hour).

Source: [illegible], 1982.

Table 6.2-11. Habitat Associations of Fish Species in the GREAT III Reach

Species	Primary Habitats*	
	Pooled River	Open River
Gizzard shad	All habitats	All habitats
Carp	All habitats	Revetted littoral; stone dike
Goldeye	Main channel border; dike field	Main channel border; stone dike
Channel catfish	Natural littoral	Natural littoral
Flathead catfish	Main channel border; revetted littoral	Main channel border; revetted littoral
Shorthead redhorse	Main channel border	Main channel border; revetted littoral
Black crappie	River lake; sloughs; navigation pool	Side channel; mouth of tributary
White crappie	River lake; sloughs; navigation pool	Side channel; mouth of tributary
River carpsucker	All habitats	Natural littoral
Bigmouth buffalo	River lake; slough; navigation pool	Side channel; mouth of tributary
Shovelnose sturgeon	Tailwaters; dike field	Main channel border
Sauger	Tailwaters; downstream end of island	Side channel
Gars (all species)	River lake; slough; navigation pool	Side channel; mouth of tributary
Largemouth bass	River lake; slough	--
Bluegill	River lake; navigation pool	--
Bowfin	River lake	--
Warmouth	River lake	--
Bullheads (all species)	River lake; slough	--

* Primary Habitat--that habitat or habitats which have the highest percent occurrence of a given species.

Source: ESE, 1982.

Table 6.2-12. Major Fish Species* Associated with Each Habitat of the GREAT III Reach

Pooled River	Open River
Tailwaters	
Freshwater drum	
White bass	
White crappie	
Shovelnose sturgeon	
Navigation Pool	
Shortnose gar	
Smallmouth buffalo	
White bass	
White crappie	
Bluegill	
River Lakes and Ponds	
Shortnose gar	
Bigmouth buffalo	
Black bullhead	
Bluegill	
Black crappie	
Sloughs	
Shortnose gar	
Smallmouth buffalo	
Bluegill	
Bullhead spp.	
Downstream End of Island	
Shortnose gar	
River carpsucker	
Sauger	
Dike Field	
Freshwater drum	
Smallmouth buffalo	
Channel catfish	
Flathead catfish	
Main Channel	**Main Channel**
Channel catfish	Channel catfish
Speckled chub	

Table 6.2-12. Major Fish Species* Associated with Each Habitat of the GREAT III Study Area (Continued, Page 2 of 2)

Pooled River	Open River
Main Channel Borders	**Main Channel Borders**
Freshwater drum	Goldeye
Flathead catfish	Flathead catfish
Channel catfish	
Side Channel	**Side Channel**
Channel catfish	Shortnose gar
Freshwater drum	Flathead catfish
	Buffalo
Natural Littoral	**Natural Littoral**
Shiners	Shiners
Channel catfish	Channel catfish
Freshwater drum	River carpsucker
	Freshwater drum
Revetted Littoral	**Revetted Littoral**
Channel catfish	Goldeye
Freshwater drum	Freshwater drum
	Pile Dike
	Goldeye
	Shortnose gar
	Stone Dike
	Freshwater drum
	Goldeye
	Shortnose gar
	Mouth of Tributary
	Shortnose gar
	Freshwater drum
	White bass

* Major species excluding gizzard shad and carp, which were abundant in all habitats. A major species makes up 5 to 10 percent or more of the total catch in a habitat or is significant for sport, commercial, or scientific reasons.

Source: ESE, 1982.

Table 6.2-13. Standing Crop of Fish Collected During Chemofishing in Kaskaskia Side Channel

Species*	#/Acre	Kg/ha
Lamprey	0.006	0.007
Chestnut lamprey	0.013	0.015
Paddlefish	0.257	0.288
Gars	54.831	61.480
Longnose gar	0.975	1.093
Shortnose gar	85.429	95.757
Gizzard shad	228.229	255.822
Threadfin shad	0.011	0.012
Grass carp	0.884	0.991
Common carp	286.563	321.209
Silver chub	0.0004	0.0005
Emerald shiner	0.013	0.015
River shiner	0.0002	0.0003
Red shiner	0.0002	0.0003
Bullhead minnow	0.0009	0.001
Minnows	0.0002	0.0003
Carpsuckers	15.992	17.925
River carpsucker	9.507	10.658
Quillback	0.916	1.027
Buffalos	55.173	61.845
Smallmouth buffalo	16.124	18.073
Bigmouth buffalo	129.464	145.116
Channel catfish	23.793	26.670
Flathead catfish	0.857	0.961
Mosquitofish	0.00009	0.0001
White bass	3.439	3.850
Orangespotted sunfish	0.0009	0.001
Bluegill	0.0009	0.001
Crappie	0.159	0.178
White crappie	0.431	0.483
Black crappie	0.142	0.159
Sauger	0.049	0.055
Walleye	0.012	0.014
Freshwater drum	10.255	11.495
TOTAL	926	1,035.183

* Taxa listed at the generic level provide data for those fish which were not identified to species and do not include data for taxa of that genus which were identified to species.

Source: ESE, 1982.

Table 6.2-14. Species, Numbers, and Length Distribution of Fish from the Ste. Geneviève Site Collected by Chemofishing

Scientific Name / Common Name	Length-mm Minimum	Length-mm Maximum	Length-mm Average	Weight-gm Minimim	Weight-gm Maximum	Weight-gm Average	Total Weight gm	Total Number Fish
Ichthyomyzon spp. / Lampreys	N.A.			N.A.		34.0	34.0	1
Ichthyomyzon castaneus / Chestnut lamprey	217.0	291.0	254.0	26.6	41.4	34.0	68.0	2
Polyodon spathula / Paddlefish	335.0	335.0	335.0	672.0	672.0	672.0	1344.0	2
Lepisosteus spp. / Gars	N.A.			N.A.		586.9	286405.7	488
Lepisosteus osseus / Longnose gar	241.0	618.0	444.9	56.0	700.0	318.5	5096.0	16
Lepisosteus platostomus / Shortnose gar	229.0	748.0	519.4	84.0	2016.0	592.6	446227.8	753
Dorosoma cepedianum / Gizzard shad	57.0	311.0	174.8	28.0	308.0	51.0	1192129.0	23359
Dorosoma petenense / Threadfin shad	69.0	75.0	72.0	28.0	28.0	28.0	56.0	2
Ctenopharyngodon idella / Grass carp	545.0	582.0	563.5	2128.0	2492.0	2310.0	4620.0	2

Table 6.2-14. Species, Numbers, and Length Distribution of Fish from the Ste. Genevieve Site Collected by Chemofishing (Continued, Page 2 of 4)

Scientific Name / Common Name	Length-mm Minimum	Length-mm Maximum / Average	Weight-gm Minimum	Weight-gm Maximum / Average	Total Weight	Total Number Fish
Cyprinus carpio / Common carp	184.0	584.0 / 437.6	56.0	3360.0 / 1305.0	[illegible]	1147
Hybopsis storeriana / Silver chub	62.0	62.0 / 62.0	2.5	2.5 / 2.5	2.5	1
Notropis atherinoides / Emerald shiner	39.0	68.0 / 50.5	0.5	2.8 / 1.7	79.5	104
Notropis blennius / River shiner	32.0	56.0 / 44.0	N.A.		1.8	2
Notropis lutrensis / Red shiner	37.0	37.0 / 37.0	1.2	1.2 / 1.2	1.2	1
Pimephales vigilax / Bullhead minnow	27.0	47.0 / 38.6	N.A.		5.2	10
Cyprinidae / Minnows F.	N.A.		N.A.		1.7	6
Carpiodes spp. / Carpsuckers	N.A.		N.A.	745.8	83533.0	112
Carpiodes carpio / River carpsucker	203.0	498.0 / 396.5	420.0	1876.0 / 775.9	49657.6	64

Table 6.2-14. Species, Numbers, and Length Distribution of Fish from the Ste. Genevieve Site Collected by Chemofishing (Continued, Page 3 of 4)

Scientific Name / Common Name	Length-mm Minimum	Length-mm Maximum / Average	Weight-gm Minimum	Weight-gm Maximum / Average	Total Weight gm	Total Number Fish
Carpiodes cyprinus / Quillback	246.0	412.0 / 343.7	168.0	784.0 / 532.0	4788.0	9
Ictiobus spp. / Buffaloes	N.A.		N.A.	1508.0	[illegible]	191
Ictiobus bubalus / Smallmouth buffalo	294.0	898.0 / 403.4	336.0	3024.0 / 979.3	[illegible]	86
[illegible] / [illegible] buffalo	293.0	616.0 / 449.6	224.0	5768.0 / 1617.8	67[illegible]	418
[illegible] / Channel catfish	47.0	692.0 / 257.6	0.9	3808.0 / 347.5	[illegible]	227
[illegible] / Flathead catfish	294.0	419.0 / 346.6	280.0	784.0 / 448.0	[illegible]	10
[illegible] / [illegible]	37.0	37.0 / 37.0	0.6	0.6 / 0.6	[illegible]	1
[illegible] / [illegible]	98.0	371.0 / 241.8	14.0	[illegible] / 206.2	[illegible]	87
[illegible] / [illegible]	N.A.		N.A.		[illegible]	1

Source: [illegible], 1982.

Table 6.2-14. Species, Numbers, and Length Distribution of Fish from the Ste. Genevieve Site Collected by Chemofishing (Continued, Page 4 of 4)

Scientific Name / Common Name	Length-mm Minimum	Length-mm Maximum / Average	Weight-gm Minimum	Weight-gm Maximum / Average	Total Weight gm	Total Number Fish
<u>Lepomis humilis</u>	39.0	52.0	1.2	2.6	7.3	4
Orangespotted sunfish		46.0		1.8		
<u>Lepomis macrochirus</u>	46.0	47.0	1.4	1.7	6.2	4
Bluegill		46.5		1.6		
<u>Pomoxis</u> spp.	N.A.		N.A.		[illegible]	5
Crappies				166.2		
<u>Pomoxis annularis</u>	74.0	287.0	4.0	476.0	2231.2	11
White crappie		197.5		204.7		
<u>Pomoxis nigromaculatus</u>	67.0	308.0	3.9	336.0	[illegible]	7
Black crappie		172.4		105.7		
<u>Stizostedion canadense</u>	161.0	231.0	28.0	140.0	254.3	4
Sauger		191.8		63.6		
<u>Stizostedion vitreum vitreum</u>	142.0	142.0	N.A.		63.6	1
Walleye		142.0				
<u>Aplodinotus grunniens</u>	26.0	357.0	0.3	3836.0	53568.0	320
Freshwater drum		205.0		167.4		

Shannon Weaver Index	1.09	Effort	1 Rotenone
Total Number	27,458	Catch/Effort	27,458.0/Rotenone
Number of Taxa	35	Total Biomass	4,823,950.8 gm

Source: ESE, 1982.

Table 6.2-15. Ichthyoplankton Occurrence in Samples Collected at Each Sampling Area, All Sampling Dates and Habitats Combined, [illegible] III Reach

Taxa	Clarksville	Winfield	Ste. Genevieve	Cape Girardeau
Dorosoma spp. or Alosa spp.	X	X	X	X
Dorosoma cepedianum			X	X
Hiodon alosoides	X		X	
Hiodon tergisus			X	X
Cyprinidae†	X	X	X	X
Cyprinus carpio or Carassius auratus	X	X	X	X
Cyprinus carpio				X
Notropis spp.	X	X		X
Notropis atherinoides	X	X		
Catostomidae*				X
Carpiodes spp. or Ictiobus spp.	X	X	X	X
Ictalurus spp.		X		
Gambusia affinis		X		
Morone spp.	X	X	X	X
Morone chrysops		X		X
Lepomis spp.	X		X	
Lepomis macrochirus			X	X
Pomoxis spp.				X
Stizostedion spp.	X		X	
Etheostomatinae	X			
Aplodinotus grunniens	X	X	X	X
Eggs	X	X		X

* Catostomidae other than Carpiodes spp. or Ictiobus spp.
† Cyprinidae other than Cyprinus carpio or Carassius auratus.

Source: [illegible], 1982.

Table 6.2-16. Summary of Ichthyoplankton Density (#/m³) Collected from the Clarksville Sampling Area, [illegible]

Taxa	April 30, 1981					June 29, 1981					September [illegible]					[illegible]				
	NL	RL	MC	NP	TW	NL	RL	MC	NP	TW	NL	RL	MC	NP	TW	NL	RL	MC	NP	TW
Dorosoma spp. or Alosa spp.		0.03					0.07													
Hiodon alosoides					0.01															
Cyprinidae				0.01	0.01		0.22	0.01	0.02	0.02										
Cyprinus spp. or Carassius spp.		0.01					0.24	0.02	0.01											
Notropis spp.										0.02										
Notropis atherinoides						0.01														
Carpiodes spp. or Ictiobus spp.		0.37	0.18	0.02	0.05	0.01	0.01	0.02	0.01											
Morone spp.		0.04																		
Lepomis spp.							0.01													
Stizostedion spp.		1.17	0.10	0.03	0.04															
Etheostomini					0.02															
Aplodinotus grunniens						0.02	0.23	0.08	0.10	0.07		0.01	0.01							
Eggs			0.01		0.09															
TOTAL	0	1.62	0.29	0.06	0.22	0.04	0.78	0.13	0.14	0.11	0	0.01	0.01	0	0	0	0	0	0	0

NL=Natural littoral; RL=Revetted littoral; MC=Main channel; NP=Navigation pool; TW=Tailwaters.

Source: [illegible], 1982.

Table 6.2-17. Summary of Ichthyoplankton Density (#/m^3) Collected from the Winfield Sampling Area, GREAT III Reach

	June 10, 1981					June 24, 1981					September 8, 1981					October 16, 1981				
Taxa	NL	RL	MC	NP	TW	NL	RL	MC	NP	TW	NL	RL	MC	NP	TW	NL	RL	MC	NP	TW
[illegible] spp. or Alosa spp.	28.32	41.62	9.93	0.36	1.80				0.02	0.01										
[illegible]	0.55	5.23	0.10	0.05	0.07															
[illegible] spp. or [illegible] spp.		0.02	0.02			0.01			0.02											
[illegible] spp.							0.01													
[illegible]						0.01								0.02						
[illegible] spp. or [illegible] spp.				0.01					0.02											
[illegible] spp.						0.01														
[illegible]										0.01										
[illegible] spp.	0.52	1.29	0.16	0.02	0.02	0.01														
[illegible]						0.02														
[illegible]	0.38	0.21	0.11	0.05	0.01	0.27	0.09	0.19	0.10	1.17	0.01		0.01	0.05	0.02					
[illegible]	0.08	0.02							0.02											
TOTAL	29.85	48.39	10.32	0.49	1.90	0.33	0.10	0.19	0.18	1.19	0.01	0	0.01	0.07	0.02	[illegible]	[illegible]	[illegible]	[illegible]	0

[illegible] littoral; [illegible] littoral; MC=Main channel; NP=Navigation pool; TW=Tailwaters.

Source: [illegible], 1982.

Table 6.2-18. Summary of Ichthyoplankton Density (#/m^3) Collected from the Ste. Genevieve Sampling Area, GREAT III Reach.

Taxa	May 13, 1981			July 17, 1981			Sept. 29, 1981			Dec. 7, 1981		
	MC	NL	RL	MC	NL	RL	MC	NL	RL	MC	NL	RL
Dorosoma or Alosa spp.	0.54	0.31	0.33			0.03						
Dorosoma cepedianum					0.01	0.01						
Hiodon tergisus		0.25	0.04									
H. alosoides	0.01		0.07									
Cyprinidae	0.02				0.01	0.04						
Cyprinus or Carassius spp.	0.04		0.03									
Carpiodes or Ictiobus spp.	0.03	0.51	0.30	0.01	0.01	0.02						
Morone spp.	0.01		0.04									
Lepomis spp.					0.05	0.02						
Lepomis macrochirus												0.01
Stizostedion spp.	0.01	0.26	0.06									
Aplodinotus grunniens	0.01			0.09	0.47	0.17						
TOTAL	0.67	1.33	0.87	0.10	0.55	0.29	0	0	0	0	0	0.01

MC=Main channel; NL=Natural littoral; RL=Revetted littoral.

Source: ESE, 1982.

Table 6.2-19. Summary of Ichthyoplankton Density ($\#/m^3$) Collected from the Cape Girardeau Sampling Area, GREAT III Reach

Taxa	June 16, 1981			July 22, 1981			September 3, 1981			November 5, 1981		
	MC	NL	RL	MC	NL	RL	MC	NL	RL	MC	NL	RL
Dorosoma or *Alosa* spp.	0.43	3.80	0.17			0.01						
Dorosoma cepedianum	0.01	0.15										
Hiodon tergisus	0.01		0.01									
H. alosoides												
Cyprinidae	0.07	0.03	0.02		0.01	0.05						
Cyprinus or *Carassius* spp.		0.03	0.01		0.03	0.04						
Cyprinus carpio	0.06	0.07	0.02			0.01						
Notropis spp.		0.02										
Catostomidae		0.02										
Carpiodes or *Ictiobus* spp.			0.03	0.01								
Morone spp.	0.01	0.10										
Morone chrysops	0.02											
Lepomis macrochirus							0.01					
Pomoxis spp.		0.09	0.03									
Aplodinotus grunniens	2.74	1.53	0.31		0.07	0.52	0.77	0.04	0.09			
Eggs					0.01							
TOTAL	3.35	5.84	0.60	0.01	0.12	0.63	0.78	0.04	0.09	0	0	0

MC=Main channel; NL=Natural littoral; RL=Revetted littoral.

Source: ESE, 1982.

6.3 BIOTIC CHARACTERIZATION OF HABITATS

The key objectives of the field data collection portion of the GREAT III ecological characterization were to:

1. Characterize the aquatic faunal communities associated with each habitat type,
2. Assess the importance of each to the river system, and
3. Describe habitat features influencing the associated biota.

The following discussion addresses these objectives on a habitat-by-habitat basis. In some cases, characteristics of a given habitat varied between pooled and open river, and these differences are noted. In most cases, primary emphasis is given to the fish, due to greater economic/recreation importance and superior existing data base. Tables 6.3-1 through 6.3-23 accompany the appropriate narratives for each habitat and provide key information on the fishes, benthic invertebrates, and habitat features.

Sections 6.3 and 6.4 provide evaluations and comparisons based largely on ESE data and quantifications (density, CPE, diversity, evenness). The limitations of the methods and efforts utilized must be considered as qualifiers of any evaluations and judgments made.

TAILWATER

The tailwater habitat was found to be a generally harsh biotic environment with many similarities to the main channel. Currents were uniformly strong and turbulent; substrates were coarse and highly scoured. Water level fluctuations could alter these characteristics. Cover was limited and strong currents precluded colonization except by current-tolerant forms. Little slackwater was available.

Benthic Invertebrates (Table 6.3-1)

No benthic invertebrate samples were collected from this habitat.

Fish

Fish were collected using electrofishing, trammel netting, otter trawling, and gill netting. Given the above-described habitat conditions, a moderately diverse fishery was found to be present, with an average diversity of 2.35. Gizzard shad dominated the catch (62 percent), followed by carp (11 percent), freshwater drum (5 percent), and white bass (5 percent).

The trammel netting method yielded very low numbers of individuals. Catch-per-effort (CPE) values for electrofishing were 63.5 and gill netting 86.6. The fishery sampled consisted predominantly of commercial (carp, drum) and forage species (gizzard shad). The most abundant sport species collected were white bass, shovelnose sturgeon, white crappie, and channel catfish.

The Winfield tailwater was significantly more productive than the Clarksville tailwater. Average CPE values were as follows for Clarksville: electrofishing, 40.6; gill netting, 20; trammel netting, 1.2, as compared with respective CPE values for Winfield of 86.3, 153, and 0.7.

Dunham (1971) found the following composition in the tailwaters of a number of navigation dams: 23.6 percent game, 39.9 percent commercial, and 36.5 percent forage. He found the following species abundance ranking, in order of decreasing abundance: gizzard shad, freshwater drum, carp, white bass, bluegill, crappie, largemouth bass, mooneye, river carpsucker, and channel catfish. Gizzard shad and carp have generally been found to be the dominant tailwater species (Bertrand and Dunn, 1973; Bertrand and Lockart, 1973). White bass and sometimes sauger were the significant sport species collected; CPE values were generally highest in spring and late summer.

NAVIGATION POOL

The principal features of the navigation pool which determine its habitat characteristics are the impoundment and regulation of water levels and flows. Depending on the control regime, the navigation pool may be completely lentic (standing water) or may grade from lentic to lotic (flowing). Regardless, there is a zone behind each lock and dam that is for the most part quiet and relatively shallow. This zone of inundation resulting from dam construction has abundant cover and hard substrates in the form of stumps, dead trees, submerged logs, and manmade structures (e.g., rock riprap).

The midriver portion of the pool approximated those conditions described for main channel and main channel border habitats, although the degree of similarity also is dependent on control regimes.

Overall, firm substrates and cover were plentiful, as were soft sediments. A diversity of current velocities and depths were available within the expanse of the navigation pool. Total habitat diversity was high because of the many features conducive to biotic development.

Benthic Invertebrates (Table 6.3-2)

Oligochaetes were the dominant benthic organisms collected in the navigation pool, comprising approximately 60 to 75 percent of the fauna at each sampling area. Chironomids were second in overall abundance. Ephemeridae (mayflies) were common. The Sphaeriidae (fingernail clams) and the Unionidae (mussels) also were found within the navigation pool.

Benthic invertebrate densities (no./m^2) ranged from 14 to 2,698/m^2 in the samples collected. Average seasonal density values at each sampling area were 979/m^2 at Clarksville and 1,159/m^2 at Winfield. The overall average density was 1,069/m^2.

Diversity values ranged from 0.00 to 2.39 in samples collected in the navigation pool. Composite diversity values were 1.51 for Clarksville

and 2.35 for Winfield, with an overall average diversity of 1.93. Composite evenness values were 1.20 for Clarksville, 1.62 for Winfield, with an overall average of 1.41

The navigation pool was found to support one of the higher overall densities of benthic invertebrates and accounted for the highest benthic diversity values recorded during the study.

Features of the navigation pool which are beneficial to benthic fauna include reduced current velocities and a variety of water depths and available substrates. Hard substrates in the form of submerged stumps and logs, aquatic macrophytes, and rock riprap generally are present in the shallow water areas around the periphery of the navigation pool. These hard substrates allow for the colonization of a diverse assemblage of macroinvertebrate organisms. In general, navigation pools provide a relatively greater degree of niche diversity, which is reflected in the productivity and diversity of associated biota.

Navigation pool features not as beneficial include frequent fluctuations in water depth and more extensive structural modifications.

Fish

Collections at the navigation pool habitat indicated that the most abundant species were gizzard shad (32.6 to 53 percent), carp (9 to 10.9 percent), shortnose gar (2.9 to 10 percent), smallmouth buffalo (4.8 to 6.5 percent), freshwater drum (8.5 to 9.2 percent), and black crappie (2.3 to 3.8 percent).

Forage, commercial, and sport species numerically dominated the navigation pool fish collections. Commonly collected commercial species were carp, smallmouth buffalo, freshwater drum, river carpsucker, and bigmouth buffalo. Abundant sport species included black crappie, bluegill, channel catfish, and white bass. Young-of-the-year green sunfish and largemouth bass were collected at this habitat.

Diversity index and evenness values (all seasons combined) were 2.70 and 1.91 at Clarksville and 3.37 and 2.35 at Winfield. The average diversity and evenness values for the two areas were 3.03 and 2.13. These values were higher than the average diversity value for all pooled river habitats. The number of species collected at this habitat also was higher than average and was surpassed only by the natural littoral habitat (seining within the natural littoral habitat yielded numerous species not collected at other habitats). Fish collection methods included electrofishing, gill netting, and frame netting, resulting in the following CPE values: 44.1 (54.8 at Clarksville and 33.2 at Winfield) for electrofishing, 44.3 (38.9 at Clarksville and 49.6 at Winfield) for gill netting and 24.5 (30.8 at Clarksville and 18.2 at Winfield) for frame netting. CPE values at the navigation pool were generally higher at the Clarksville site than at the Winfield site.

The navigation pool supports a diverse and abundant assemblage of commercial, forage, and sport fishes. Factors contributing to the presence of an abundant ichthyofaunal community include:

1. A variety of water depths;
2. A variety of substrate types;
3. Large amounts of slack water area; and
4. Availability of protective cover around the periphery of the pool in the form of stumps, snags, and rocks.

RIVER LAKE

The river lake is a unique habitat in the river system in that it is a totally lentic (standing water) habitat, having no connection with any of the other identified habitat types under normal water level conditions. In addition to the absence of flowing water, key habitat features include relatively shallow water depths, soft, flocculent, organically enriched substrates, abundant cover (notably aquatic macrophytes), and isolation from other riverine biological communities (except during high water).

Habitat suitability is reduced as water levels fall and during periods of depressed dissolved oxygen. Also, lentic characteristics preclude utilization by flowing-water faunal forms. Nevertheless, the river lake is one of the most productive habitats in the study area.

Benthic Invertebrates (Table 6.3-3)
The dominant benthic invertebrate taxa collected in the river lake habitat was Oligochaeta (60 to 70 percent). A majority of the remaining benthic organisms were chironomids and ceratapogonids. Hemiptera and Coleoptera taxa were collected (less than 5 percent); these taxa were collected in few other samples or habitats.

Density values ranged from 488 to $2,856/m^2$ in the samples collected. Average seasonal density was $922/m^2$ at Clarksville and $2,085/m^2$ at Winfield. Overall average density was $1,503/m^2$.

Diversity values ranged from 0.53 to 2.61, with composite diversity values of 1.97 at Clarksville and 2.31 at Winfield. Overall, average diversity for all river lake locations was 2.14. Composite evenness values were 1.57 for Clarksville, 1.75 for Winfield, with an overall average of 1.66.

The overall average density of the river lake was second only to that of the slough habitat, while the overall average diversity was exceeded only by that of the navigation pool; evenness values were among the highest as well. Both the slough and navigation pool have habitat characteristics quite similar to those of the river lake.

Features of the river lake conducive to benthic development include higher primary productivity, absence of current, stable substrates, and an abundance of cover and hard surfaces (stumps, logs). Nonconducive features included the soft, flocculent nature of some substrates, the presence of eutrophic conditions, the potential for extreme water level reductions during summer drought and periodic decreases in dissolved oxygen.

In spite of all these potential limiting factors, the river lake is one of the key benthic habitats in the river system.

Fish

River lake fish sampling produced widely differing results between the two sampling sites. Species abundant at both sites were gizzard shad (13.6 to 38.9 percent), carp (6 to 2.9 percent), shortnose gar (2.2 to 9.9 percent), black bullhead (8.8 to 22 percent), and bluegill (2.9 to 21.8 percent). Species abundant exclusively at the Winfield river lake were black crappie (17.6 percent), white crappie (3 percent), largemouth bass (4.2 percent), and white bass (2 percent). Species abundant only at the Clarksville site were limited to bigmouth buffalo (4.3 percent).

In addition to abundant species present in the collections, some less abundant species were collected almost exclusively at the river lake habitat. These species were warmouth, brown bullhead, yellow bullhead, bowfin, spotted gar, yellow bass, and green sunfish. These species were primarily collected from the Winfield river lake.

Collections of sport fish dominated the Winfield river lake collection. The Clarksville collections were numerically dominated by forage and commercial species. Abundant sport fishes in the collections were bluegill, black bullhead, crappie (black and white), largemouth bass, and white bass. Forage fish were dominated by gizzard shad. Commercial species collected in abundance included carp, bigmouth buffalo, and smallmouth buffalo. Abundant predatory non sport or commercial species included shortnose gar and bowfin. Young-of-the-year green sunfish, bluegill, largemouth bass, white crappie, black crappie, carp, and black bullhead were collected at the river lake habitat.

Diversity index and evenness values for the river lake habitat were 2.45 and 1.95 for Clarksville and 3.06 and 2.14 for Winfield. The combined diversity and evenness values were 2.75 and 2.04, respectively. These values were similar to the average values for all pooled river habitats.

In addition, a higher than average number of species (average per pooled river habitat) was collected at the river lake habitat. Fish were collected with electrofishing, gill netting, and frame netting. CPE values were, respectively, 84.6 (35.1 at Clarksville and 100.9 at Winfield), 131.3 (114.5 at Clarksville and 148.2 at Winfield), and 35.9 (11.8 at Clarksville and 59.9 at Winfield).

The collections indicated that the river lake habitat is an important habitat for the ichthyofaunal communities in the pooled river. These habitats support a diverse and abundant assemblage of fish. This is particularly true for many sport species which were found in their greatest abundance in the river lake habitat (particularly at Winfield). The importance of each individual river lake is apparently based on successional stage or eutrophic conditions. Those lakes which are shallow and filled with organically enriched silts and clays and detritus support low sport fish communities and higher commercial and forage fish communities (i.e., Clarksville sampling area). Lakes which are less eutrophic and contain deeper water areas and less sediment support diverse sport fish communities (i.e., Winfield sampling area).

SLOUGHS

Those features of slough habitats significant to aquatic biota include:

1. Lack of (or very limited) current;
2. Soft, organically-enriched substrates;
3. Shallow water depths, and
4. Abundance of cover in the form of aquatic macrophytes as well as submerged stumps and logs.

Sloughs closely resemble lentic (standing water) habitats, but also are influenced by their connection to other aquatic habitats. Flowing water conditions do occur within sloughs during flooding, heavy surface runoff and, in the pooled river, during the drawdown of the navigation pools.

Sloughs are typically the most [illegible] aquatic habitat in the [illegible] system. Sloughs also are subject to [illegible] temperature and dissolved oxygen during certain times of the year. However, the slough remains a highly productive habitat for aquatic biota because of the richness of organic detritus, the [illegible] abundance of primary producers, and the presence of cover and hard substrates (logs, stumps).

Benthic Invertebrates (Table [illegible])

The benthic fauna of the slough habitats sampled consisted almost exclusively of Oligochaeta (65 to 70 percent) and Chironomidae ([illegible] to 25 percent). Sphaeriidae (clams) and Hexagenia spp. (mayflies) were the only other taxa consistently represented, but they represented less than 5 percent of the total.

Density values ranged from 172 to 2,[illegible]/m² in samples collected during the study. Average seasonal density at the Clarksville slough was 2,691/m² and at the Winfield slough 1,270/m². The overall average density among all seasons and stations was 1,980/m².

Diversity values ranged from 0.[illegible] to 1.[illegible] during the study. [illegible] diversity was 1.65 at Clarksville and 1.[illegible] at Winfield. The overall average diversity was 1.[illegible] for slough habitats. [illegible] values were 1.3[illegible] for Clarksville, 1.[illegible] for Winfield, [illegible] average evenness of 1.21.

Overall, the slough areas [illegible] importance of [illegible] [illegible] sloughs provide features suitable to benthic development [illegible] primary productivity, abundant available food [illegible] stable bottom types. Features which can limit benthic [illegible]

include periodic reductions in water volume, resulting [illegible] of substrates, and reductions in dissolved oxygen.

Fish

Examination of slough habitats was restricted to the [illegible] portion of the study area. Collections at the slough habitat indicated that the most abundant species were gizzard shad (38.4 to 45.7 percent), shortnose gar (7.6 to 10.6 percent), carp (1.7 to 11.5 percent), bluegill (2.7 to 23 percent), smallmouth buffalo (9.8 percent at Winfield), and freshwater drum (7.8 percent at Winfield.)

The slough habitat collections produced high numbers and catch-per-unit effort values for all categories of fishes except the omnivorous non-sport or commercial category, which were never abundant. Common forage species in the samples were gizzard shad and emerald shiner. Commercial fishes collected in abundance included carp, smallmouth buffalo, and freshwater drum. Abundant sport species included bluegill, crappie (white and black), black bullhead, and channel catfish. In the collections at the slough habitat, the predominant predatory non-sport or commercial species was the shortnose gar. Bertrand and Dunn (1973) found gizzard shad, carp, bluegill and drum as the dominant species in slough habitats. Thirty-eight percent of the total catch was sport fish dominated by bluegill, crappie, channel catfish, and largemouth bass. Carp and buffalo were the most abundant commercial species.

Composite diversity of fish collections was 2.69 at Clarksville and 3.0[illegible] at Winfield, with an overall average of [illegible]. [illegible] evenness values were 2.07 and 2.1[illegible] with an [illegible]. Average CPE values were 86.0 ([illegible]) for electrofishing, 39.3 (72.0 at Clarksville and [illegible]) gill netting and 23.9 (23.0 at Clarksville and [illegible]) trawl netting.

Overall diversity, evenness, and CPE values were well above the averages of all habitats, indicating the value of the slough habitat for fish production. In addition, the slough habitat likely serves an important role as a spawning and nursery habitat for a number of fish species. Bertrand and Dunn (1973) reference the value of sloughs as spawning and/or nursery habitat for sunfish, bluegill, crappie and buffalo. Collections made during the GREAT III study include young-of-the-year bluegill and river carpsucker in the samples.

DOWNSTREAM END OF ISLAND

The habitat located downstream of major river islands combines features of several habitats, especially sloughs and littoral habitats. The habitat varies, depending on orientation in relation to major currents and shoreline configuration (i.e., degree of "cut" into the island).

Key habitat features include:

1. Relatively shallow, but variable, water depths;
2. Zones of slack water, as well as current;
3. Variety of substrate types; and
4. Generally abundant cover in the form of logs, shoreline vegetation, and perhaps aquatic macrophytes.

Benthic Invertebrates (Table 6.3-5)

Oligochaetes dominated the benthos of this habitat, averaging 87 percent of the total benthos. Chironomids and *Hexagenia* spp. were next in relative abundance.

Density values ranged from 14 to 3,803/m^2 in the samples collected. Seasonal average density values for the two sampling areas were 2,468/m^2 for Clarkeville and 495/m^2 for Winfield.

Diversity values ranged from 0.00 to 1.97 in the samples collected. Compositing the four seasons, diversity at Clarksville was 0.82 and at Winfield 1.40 and evenness values were 0.74 for Clarksville and 1.40 for Winfield.

The overall average density, diversity, and evenness for this habitat were $1,481/m^2$, 1.11, and 1.07, respectively. In comparison to the other habitats sampled, the downstream-end-of-island habitat supports generally one of the higher overall densities of benthos, but supports one of the lower overall benthic diversities and evenness values.

Fish

In the downstream island habitat a moderate number of fish was collected resulting in a relatively high diversity. The dominant fish were gizzard shad (44 percent), followed by carp (12 percent), shortnose gar (9 percent), freshwater drum (5 percent), and river carpsucker (4 percent).

Composite diversity values were 3.25 for Clarksville and 2.88 for Winfield. The average diversity for the habitat type was 3.07. Average catch-per-effort (CPE) values were as follows: electrofishing 17.9, (13.9 at Clarksville and 21.8 at Winfield), gill net 33.7 (32.6 at Clarksville and 34.8 at Winfield), and frame net 7.3 (9.0 at Clarksville and 5.7 at Winfield). Composite evenness values were 2.27 for Clarksville, 1.99 for Winfield, averaging 2.13.

Categorical composition of the catch was a generally even distribution of sport, commercial, and forage species. Carp was the most abundant commercial species collected. The most common forage species was gizzard shad, and white bass was the most common sport species. Other common sport species were sauger, channel catfish, black crappie, and white crappie. Young-of-the-year green sunfish and largemouth bass were also collected.

In comparison with the other habitats, diversity and evenness were above average in this habitat, whereas abundance, as measured by CPE, was below average.

Factors influencing the diversity and productivity included the limited areal extent of the habitat and perhaps the instability of current and water level conditions due to hydrologic dynamics at the downstream tips of the islands.

DIKE FIELDS (STONE)

Habitat features of dike fields resembled those of the main channel border habitats. Substrates were generally soft and relatively stable, except in zones of abrasion. Cover was present in the form of natural logs, snags, and debris. Current velocities ranged from slackwater zones near shore, to strong currents where water flows over dikes and at dike tips. The rock riprap of the dikes provided excellent substrate for benthic invertebrate colonization, although only soft substrates were sampled. All of the above factors enhance the suitability of the dike fields for aquatic fauna.

Benthic Invertebrates (Tables 6.3-6, 6.3-7)

The dominant taxon in the dike field habitat was Oligochaeta at all sampling areas, ranging from 50 to 75 percent of the total benthos. Chironomids were second in relative abundance in the pooled river; Hexagenia spp. was second in the open river. The taxa Isopoda (aquatic sowbugs), Ephemeroptera, Hydropsychidae (caddisflies), and Pelecypoda were common.

Densities ranged from 43 to 2,727/m^2 during the study. Seasonal average density values were 1,589/m^2 at Clarksville, 771/m^2 at Winfield, 366/m^2 at Ste. Genevieve, and 161/m^2 at Cape Girardeau.

Diversity ranged from 0.00 to 3.00 during the study. Composite diversity values were 1.57 at Clarksville, 2.39 at Winfield, 1.91 at Ste. Genevieve, and 1.36 at Cape Girardeau. Respective composite evenness values were 1.15, 1.81, 2.11, and 1.61.

Average density, diversity, and evenness values for the pooled river were $1,177/m^2$, 1.98, and 1.48 respectively, and for the open river $263/m^2$, 1.64, and 1.86.

The overall average diversity, evenness, and density values were 1.81, 1.67, and $720/m^2$, respectively. This diversity value was the highest overall diversity determined. Although the overall density was comparatively low among the habitats, the comparatively high diversity and evenness indicate that the dike fields support an assemblage of benthos not well represented in other habitats. This is probably because of dike riprap and the diversity of current and substrate conditions conducive to benthic development.

Grace and Weithman (1982) sampled benthic invertebrates of stone dikes (River Miles 95-115) during 1981, using both artificial substrates and dredge samplers. They found that 85 percent of the total benthos was composed of Oligochaeta (59 percent), Ephemeropte- (14 percent), and Diptera (12 percent). Trichoptera and Odonata were also common. Invertebrate abundance was greatest in spring, lowest in the summer.

ESE's ponar grab samples in similar habitats in nearby sites showed a different composition than that of Grace and Weithman. ESE found Oligochaeta comprised 50 percent of the fauna, Ephemeroptera 47 percent, and Diptera 3 percent (Appendix Table B-3). No Trichoptera or other taxa were found.

Fish

Dike fields (stone) in the open and pooled river segments supported a generally similar fishery. The dominant fish collected from the pooled and open river, respectively, included carp (28 and 49 percent), gizzard shad (20 and 26 percent), freshwater drum (16 and 8 percent), smallmouth buffalo (5 and 0.5 percent), white bass (2.6 and 3 percent), and channel catfish (4 and 3 percent).

Composite diversity and evenness values were 3.27 and 2.47 at Winfield, 3.03 and 2.06 at Clarksville, 2.18 and 1.70 at Ste. Genevieve, and 2.33 and 1.86 at Cape Girardeau. Average diversity and evenness for the pooled river were 3.15 and 2.36, and for the open river 2.26 and 1.78. The overall diversity and evenness for the habitat type were 2.71 and 2.07, respectively. In all cases, diversity values were well above the average for all habitat types.

Productivity, as measured by CPE, was generally below average for the dike fields. Average CPE values for the pooled and open river, respectively, were electrofishing (29.7 and 48.2), trammel netting (1.8 and 0.5), gill netting (4.7 and 6.0), and hoop netting (1.1 and 0.7). CPE values at Clarksville, Winfield, Ste. Genevieve, and Cape Girardeau respectively were electrofishing (30.6, 28.9, 48.7, 47.8), trammel netting (0.1, 3.5, 0, 0.9), gill netting (1.0, 8.5, 6.0, 0) and hoop netting (0.9, 1.5, 0.4, 1.1).

The commercial fish category numerically dominated collections in the dike fields, with sport and forage species represented to a lesser extent. Carp and freshwater drum were the major commercial species and gizzard shad was the major forage species. The most common sport species collected were channel catfish, flathead catfish, white bass and, in the pooled river, bluegill. The major fish species associated with the dike fields, other than carp and gizzard shad, included freshwater drum, smallmouth buffalo, channel catfish, flathead catfish, and white bass.

Overall, the dike field is a moderately valuable habitat for fish based on above average diversity and below average productivity values. A diversity of current and substrate conditions is present, and cover is available. In the open river, the dike field habitat provides zones of slack water and cover which are not otherwise common in the open river. The importance of this habitat, however, is variable, based upon CPE

values, with those at Cape Girardeau being much higher than CPE values at the Ste. Genevieve site.

Grace and Weithman (1982) intensively sampled fish populations associated with stone dikes in River Miles 95-115, concurrent with ESE's sampling year. They found that 85 percent of the fish consisted of the following species: gizzard shad (53 percent), carp (10 percent) river carpsucker (8 percent), freshwater drum (6 percent), shortnose gar (3 percent), emerald shiner (3 percent), and flathead catfish (2 percent). A total of 45 species was collected, with highest CPE values obtained at intermediate river levels. The most common sport fish not listed above were channel catfish, blue catfish, white bass, and white crappie.

MAIN CHANNEL

The main channel of the Mississippi River provides little suitable habitat for most fish and benthic invertebrates. Currents are continually strong, and water depths are generally the greatest found in the river. Substrates range from limited rock exposures to sand-gravel and hard packed mud. Scouring of substrates by fast moving water is also a factor (Tables 6.3-8 and 6.3-9).

No benthic invertebrate collections were made in the main channel due to depths and strong currents. Fish were collected using otter trawl and floating trammel net, although neither method produced any significant catches.

Only 61 individuals were collected from the main channel, a majority of these being speckled chub, channel catfish (YOY), and gizzard shad. Shovelnose sturgeon, bigmouth buffalo, quillback, freshwater drum (YOY), river shiner, and western sand darter were also collected. LGL Associates (1981) intensively sampled the main channel in the pooled river (Miles 500-513) and found that channel catfish was the dominant

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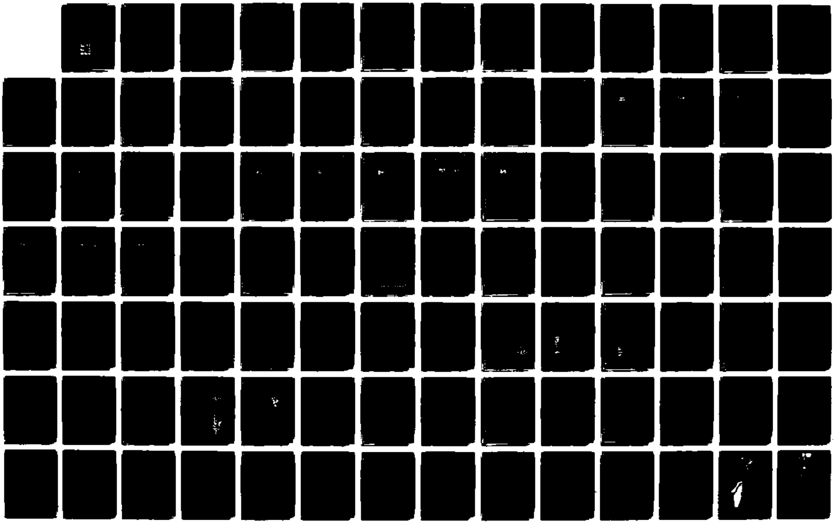


species [illegible] (10 percent) [illegible]
(2.5 percent), flathead catfish (2 percent) [illegible]
(2 percent). This would suggest that [illegible]
[illegible]
[illegible]
catfish [illegible]
[illegible] were collected in [illegible]
[illegible] The main channel [illegible]
to be utilized by [illegible]

MAIN CHANNEL BORDER

The main channel border represents an ecological transition between the main channel habitat and near shore (littoral) and backwater habitats. Depths decrease as does current velocity, in most cases. Substrates become less coarse but are generally more stable, and slightly more cover is available. Primarily because of current, depth, and substrate variability, the main channel border has been categorized into three habitat types:

1. Inside bend,
2. Outside bend, and
3. Straight stretch.

Each will be discussed separately.

Main channel border habitat is [illegible]
with gradations in depth, substrate, and cover [illegible]
channel to near shore. These gradations [illegible]
[illegible]
[illegible]

Outside Bend [illegible]
Relative to the other [illegible]
generally [illegible] deeper [illegible]
[illegible] beyond [illegible]

[illegible]

[illegible] bend and straight [illegible]

Benthic macroinvertebrates [illegible] from approximately 60 to [illegible] percent of the total [illegible]. [illegible] taxa were more abundant within the [illegible] other habitats. [illegible] mayfly taxa, which generally were [illegible]. Sphaerid clams also were common in the [illegible].

Density values ranged from 43 to 3,[illegible]/m^2. [illegible] were 1,[illegible]/m^2 at Clarksville, [illegible] at Winfield, [illegible] Ste. Genevieve, and [illegible]/m^2 at Cape Girardeau.

Diversity ranged from 0.00 to [illegible]. Composite diversity was [illegible] at Clarksville, 0.92 at Winfield, [illegible] at Ste. Genevieve, and [illegible] at Cape Girardeau. Respective composite evenness values were [illegible], and 0.83.

The average pooled river density, diversity, and evenness were 1,299/m^2, 1.49, and 1.24 respectively, and [illegible] respectively, for the open river. [illegible] were variable between sampling sites, [illegible] density and diversity were [illegible] the [illegible] river.

Overall density, diversity, [illegible] respectively. [illegible] habitat; therefore, [illegible] among the [illegible] of [illegible]

[illegible]

[illegible] flathead [illegible] pooled river.

[illegible]

The diversity value for Cape [illegible] and the average values for the [illegible] other diversity values were below average.

[illegible]

Overall, the outside bend habitat [illegible] as a [illegible] fishery habitat compared to other main channel [illegible]. The relative importance of this habitat [illegible] the higher CPE values at the [illegible] the Cape Girardeau site in the open river. [illegible] community development include strong currents, unstable [illegible] sediments, and limited availability of cover as compared to many other habitats and to the other main channel border habitats.

Inside Bend (Tables 6.3-12 and 6.3-13)

In comparison to the outside bend and straight stretch main channel borders, the inside bend provides more suitable environmental conditions for the support of biotic communities. This habitat is generally much wider than the other two and is characterized by greater habitat gradations. Overall currents are slower, substrates are finer (more stable and less scoured), and more cover (snags, logs) is available.

Benthic Invertebrates--Although the benthic invertebrate community of the main channel border (Inside Bend) varied between pooled and open river, it was generally dominated by Oligochaeta (70 to 90 percent depending on sampling area). Chironomids were generally second in relative abundance. Hydropsychidae (caddisflies) were more common than in most habitats, and Sphaeriidae were well represented. Hydropsychidae were most abundant at Winfield and Cape Girardeau. Both groups are tolerant to moderately tolerant of pollution and are more closely associated with firm substrates.

Benthic density values ranged from 86 to 2,[illegible]/m² in the samples collected. Average seasonal density values for each sampling area were 1,2[illegible]/m² at Clarksville, 1,[illegible] at Winfield, [illegible] St. [illegible], and [illegible] at Cape Girardeau.

Diversity values [illegible]

Composite diversity values [illegible]

0.76 at Ste. Genevieve, and 0.81 at Cape Girardeau. Respective evenness values were 0.82, 1.35, 0.90, and 1.70

The average pooled river density, diversity, and evenness were $1,277/m^2$, 1.41, and 1.08, respectively, and for the open river $157/m^2$, 0.79, and 1.30, respectively.

The overall average density, diversity, and evenness for the inside bend were $717/m^2$, 1.10, and 1.19, respectively. These values place this habitat in about an average position compared to other habitats. Factors influencing the density and diversity of benthos include strong currents, deeper water, scoured and shifting sediments, and lack of cover.

<u>Fish</u>--The fish numerically dominating the inside bend habitat varied somewhat between the pooled and open river. In the pooled river, the five most common species were carp (30 percent), freshwater drum (21 percent), gizzard shad (20 percent), channel catfish (7 percent), and flathead catfish including young-of-the-year (5 percent). In the open river, the following species were most common: gizzard shad (32 percent), goldeye (23 percent), flathead catfish (15 percent), freshwater drum (9 percent), and shorthead redhorse (6 percent).

Composite diversity and evenness values were 2.76 and 2.24 at Clarksville, 2.72 and 2.31 at Winfield, 2.92 and 2.48 at St. Genevieve, and 2.11 and 1.96 at Cape Girardeau, indicating few diversity or evenness differences between sampling areas.

Average diversity and evenness were 2.74 and 2.28 for the pooled river and 2.51 and 2.22 for the open river. Overall average diversity and evenness for the inside bend habitat were 2.63 and 2.25, respectively. All of the diversity values for this habitat are above the average values for habitat types.

CPE values for the pooled and open river, respectively, were electrofishing (33.8 and 10.3), trammel netting (0.2 and [illegible]), gill netting (0.5 and 31.0), and hoop netting (0.9 and 0.8). With the exception of gill netting on the open river, the CPE values were below the average for habitats. CPE values at each site from Clarksville through Cape Girardeau were, electrofishing (33.9, 27.2, 4.0, 16.9), trammel netting (0.3, 0, 0.4, 0) gill netting (0, 1.0, 1.0, 62.0) and hoop netting (0.5, 1.2, 1.0, 0.8).

Commercial and sport species were the best represented categories in the inside bend. Freshwater drum and carp were the most abundant commercial species, and channel and flathead catfish were the most abundant sport species. The other more commonly collected sport species included white bass, black crappie, and, in the open river, blue catfish and sauger.

The major species associated with the inside bend habitat in the pooled river were freshwater drum, flathead catfish, and channel catfish. In the open river, they were goldeye and flathead catfish.

Differences between the pooled and open river fish communities were primarily related to differences in dominance and percent occurrence, notably for goldeye and shorthead redhorse.

The inside bend habitat was evaluated as a moderately valuable habitat overall, although CPE values were below average. Habitat factors which influence fishery value include relatively shallow waters, abundant cover, and relatively stable substrates.

Straight Stretch (Tables 6.3-14 and 6.3-19)
The straight stretch main channel border represents an intermediate habitat between the inside and outside bend habitats. Substrates grade from coarse near midriver to fine near shore, with similar [illegible] in scouring and increases in substrate stability. The [illegible] of [illegible] increases closer to shore. Therefore, suitability for aquatic [illegible]

increases as one nears shore, and the overall biotic suitability of the straight stretch is categorized as between that of the inside and outside bends.

Benthic Invertebrates--Typically, Oligochaeta dominated the benthic fauna of this habitat, although its relative abundance varied from [illegible] to 95 percent depending on the sampling area. [illegible] were [illegible] second in relative abundance. Trichoptera and Ephemeroptera were more common than in most habitats, especially in the pooled river. Sphaerids also were common.

Density varied from 0 to 2,597/m^2. Seasonal average density values were 670/m^2 at Clarksville, 1,726/m^2 at Winfield, 53/m^2 at Ste. Genevieve, and 153/m^2 at Cape Girardeau.

Diversity ranged from 0.00 to 2.50. Composite diversity values were 2.34 at Clarksville, 0.91 at Winfield, 2.33 at Ste. Genevieve, and 0.26 at Cape Girardeau. Respective composite evenness values were 1.77, 0.76, 2.75 and 0.75.

Average pooled river density, diversity, and evenness were [illegible]/m^2, 1.63, and 1.27, respectively, and open river values were 103/m^2, 1.30, and 1.64, respectively.

The overall density, diversity, and evenness values were 600/m^2, 1.47, and 1.46, respectively. This density value is one of the lower overall densities for the habitats considered; diversity and evenness values were about average among habitats. Factors limiting benthic development included current velocities, sediment scour, and [illegible].

The straight-stretch habitats were highly variable among areas [illegible] with the Winfield straight stretch being rated overall as [illegible] suitable for benthic fauna, based on density and [illegible].

Fish--The [illegible] composition of the [illegible] habitat was generally comparable to that of the other main channel [illegible]. Dominant species, with percent occurrence, were gizzard shad ([illegible] to 65 percent), carp (21 to 7 percent), and freshwater drum ([illegible] to 5 percent). Channel catfish ([illegible] percent) and [illegible] ([illegible] percent) were common in the pooled river, whereas goldeye ([illegible] percent) and flathead catfish (3 percent) were common in the open river.

Fish diversity and evenness values (composite) were [illegible] and [illegible] at Clarksville, 2.88 and 2.39 at Winfield, 1.[illegible] and [illegible] at Ste. Genevieve, and 2.61 and 2.04 at Cape Girardeau. Average diversity and evenness values were 3.09 and 2.[illegible] for the pooled river and 1.91 and 1.50 for the open river. Overall average diversity was [illegible] and evenness 1.95. In general, these values were slightly above the averages for all habitats.

CPE values indicate generally higher than average productivity for the straight-stretch habitats. The following CPE values were recorded for the pooled and open river, respectively: electrofishing (32.3 and 50.1), trammel netting (0.9 and 0.1), gill netting (2.0 and 6.0), and hoop netting (1.5 and 1.4). CPE values for specific sampling sites at Clarksville, Winfield, Ste. Genevieve, and Cape Girardeau, respectively, were electrofishing (27.5, 37.2, 81.7, 18.6), trammel netting (1.4, 0.3, 0.2, 2.0), gill netting (2.0, 2.0, 0, 12), and hoop netting (0.9, 1.6, 1.5, 1.3).

Forage fish were the most abundant group, represented primarily by gizzard shad. Commercial species, primarily carp and [illegible], were common. Channel catfish and flathead catfish, [illegible], also were abundant. The major species [illegible] in the [illegible] stretch were freshwater drum, goldeye, and [illegible]. Other more commonly collected sport species [illegible] crappie, and, in the open river, [illegible].

Overall, the straight [illegible]

[illegible] conditions, the available [illegible] depths, and current. Compared to other habitats, the straight [illegible]

Literature sources reviewed did not differentiate the three main channel border types; therefore, the following synopsis pertains to the main channel border in general. Carp, gizzard shad, and drum have been consistently indicated as the most abundant species in this habitat, with bluegill being abundant in the pooled river and [illegible] and shortnose gar abundant in the open river. This habitat consistently yielded much lower CPE values than other habitats sampled, with 12 to 25 percent of the collections being sport species and the remainder heavily dominated by commercial and forage species. Crappie, bluegill, white bass, catfish, and sauger were the most abundant sport species (Bertrand and Dahm, 1973; Bertrand and Lockart, 1973; Bertrand and Allen, 1973; England, 1976).

SIDE CHANNEL[illegible]

Side channel habitats have been considered among the most [illegible] biologically productive habitats [illegible] which are generally soft, but stable, with little current [illegible] Cover is generally abundant and includes snags and logs, as well as [illegible]

fluctuations and resulting deposition/scouring of substrates, and (2) periodic fluctuations of dissolved oxygen and temperature during low flow conditions.

Fish

The fish community within the side channel habitats was numerically dominated by gizzard shad (14 to 56 percent), carp (48 to 13 percent), shortnose gar (3 to 11 percent), freshwater drum (7 to 3 percent), channel catfish (9 to 1 percent), and white bass (2 percent). Gizzard shad and carp were abundant at all four sampling sites. Channel catfish, white bass, and shortnose gar abundance varied among locations.

Dominant categories of fish in the side channel collections were commercial (pooled river) and forage (open river). Abundant commercial species, along with carp, were freshwater drum, river carpsucker, and smallmouth buffalo. Gizzard shad was the predominant forage species. Sport species were generally collected in moderate numbers with the highest catch-per-effort values occurring at the Cape Girardeau sampling area. The most commonly collected sport species were channel catfish, white bass, white crappie, flathead catfish, and, in the pooled river, bluegill.

Composite diversity and evenness values for the side channel habitats averaged 2.37 and 1.97 at Clarksville, 2.72 and 2.06 at Winfield, 2.95 and 2.17 at Ste. Genevieve, and 1.49 and 1.19 at Cape Girardeau. The diversity index value for the two pooled river sites combined was 2.55, whereas the combined open river value was 2.37. The combined diversity index value for all four sites was 2.49. Evenness values averaged 2.02 for the pooled river, 1.68 for the open river, and 1.85 overall.

When comparing all habitats within the pooled portion of the river, the diversity and evenness of the side-channel fisheries community were lower than average. In the open river, side channel diversity and

evenness values were similar to the average value for all habitats. Additionally, many of the sport as well as the predatory nonsport or commercial fish collected during open river sampling were captured at side channel locations.

The number of species collected at the side channel habitat paralleled the diversity values. Study results indicated that a higher than average number of species-per-habitat was collected at the open river (compared to all other open river habitats) and a lower than average number was recorded for the pooled river (compared to all other pooled river habitats).

CPE values at the side channel habitat also indicate higher than average values for the open river side channel habitat compared to other open river habitats and lower than average values for the pooled river habitat compared to other pooled river habitats. Average CPE values for the pooled and open river *side channels* respectively were electrofishing (25.7, 55.3), trammel netting (0.4, 1.3), and gill netting (1.3, 29.0). CPE values for each site respectively, Clarksville through Cape Girardeau, were electrofishing (28.9, 22.6, 15.9, 94.8), trammel netting (0.7, 0, 2.0, 0.7), and gill netting (1.0, 1.5, 29.0, 0). The data collected during the chemofishing portion of the study support the main portion of the study in indicating the importance of the side channel habitat in the open river. The chemofishing data indicated that the side channel studied supported a large assemblage of species (35 taxa) and high biomass (926 lbs. per surface acre) under low flow conditions. Young-of-the-year channel catfish and white crappie were also collected during the chemofishing study.

Several side channel fisheries investigations have been conducted in the pooled and open river, including collections in Picayune and Kaskaskia Chutes, which were sampled in the present study. Gizzard shad, carp,

shortnose gar, river carpsucker, drum, and bluegill have generally been found to be the more abundant species in side channels. Sport species percentages ranged from 10 to 29 percent with bluegill, crappie, white bass, largemouth bass and channel catfish comprising the majority of sportfish. Gizzard shad, emerald shiner, bullhead minnow, and river shiner have been found to be the most abundant forage species. Evidence indicates that most of the non-forage species listed above utilized side channels as spawning and/or nursery areas (Bertrand and Dunn, 1973; Bertrand and Lockart, 1973; Bertrand and Allen, 1973; Bertrand and Garver, 1973; Ragland, 1974).

LITTORAL HABITAT

The littoral habitat combines features of quiet backwaters with those of main river habitats. Water is relatively shallow with at least moderate current at most times. The natural littoral zone provides sediments which are generally soft and unstable, especially in zones of bank erosion. The revetted littoral habitat provides a majority of substrate in the form of rock riprap. Cover in the form of logs, snags, and bank vegetation is common in the natural littoral habitat, but very limited in the revetted littoral habitat. Another factor of major biologic influence in the littoral habitats is the frequent fluctuation of water level, due to natural hydrologic changes and wave action from barge traffic.

Natural Littoral (Tables 6.3-18 and 6.3-19)

Benthic Invertebrates--The predominantly soft, unstable substrates of the natural littoral habitats resulted in benthic collections which were very low in diversity and strongly dominated by oligochaetes and chironomids.

Density values indicated relatively high productivity despite the low diversity and ranged from 0.0 to 6,486/m^2 during the study. Average seasonal density values were 1,370/m^2, 2,927/m^2, 205/m^2, and 54/m^2 for the sampling areas in downstream order.

Diversity values ranged from 0.00 to 0.99 during the study, with composite diversities of 0.47, 0.23, 0.56, and 1.07 for the four sampling areas and composite evenness values of 0.52, 0.23, 0.93, and 1.78 for the four areas.

Average density, diversity, and evenness values were $2,149/m^2$, 0.35, and 0.38, respectively, for the pooled river and $129/m^2$, 0.82, and 1.36 for the open river.

Overall average density, diversity, and evenness values were $1,139/m^2$, 0.59, and 0.87, respectively. This was the lowest overall diversity determined, although the density value of this habitat is rated at midpoint among the habitats considered.

Fish--The natural littoral habitat yielded a fish fauna somewhat different than that of other habitats. This was due in part to the fact that seining was not conducted at other habitats. Dominant species in the pooled river were emerald shiner (44 percent), river shiner (23 percent), channel catfish (6 percent), carp (6 percent), and gizzard shad (5 percent). In the open river, dominant species were gizzard shad (45 percent), emerald shiner (33 percent), river shiner (6 percent), and channel catfish (3 percent). Young-of-the-year of numerous species including centrarchids, cyprinids, hiodontids, catastomids, gizzard shad, shortnose gar, carp, mosquitofish, skipjack herring, white bass, channel catfish, and freshwater drum were collected at the natural littoral habitat.

Composite and average diversity values were slightly above averages for all habitats, due primarily to the variety of species typically collected by seining and to the effectiveness of electrofishing in shallow waters. Composite diversity and evenness values were 3.12 and 2.00 for Clarksville, 2.15 and 1.43 for Winfield, 2.05 and 1.60 for Ste. Genevieve, and 2.22 and 1.53 for Cape Girardeau. Average diversity and evenness values were 2.64 and 1.72 for the pooled river and 2.14 and

1.56 for the open river, with overall averages of 2.39 and 1.64. Evenness values were generally below averages of all habitats.

Collection methods included electrofishing and seining only. CPE values for the pooled and open river, respectively, were electrofishing (29.1 and 19.5) and seining (260.7 and 170.3). CPE values for each site respectively (Clarksville through Cape Girardeau) were electrofishing (24.6, 33.7, 17.7, 21.2) and seining (181, 340.3, 36.7, 303.9). The average values for electrofishing were well below the average for all habitats, but the high CPE values for seining establish the relatively high productivity of this habitat, especially for forage species.

Forage species numerically dominated the littoral habitat, notably the emerald and river shiners and gizzard shad. Commercial species were numerically dominated by carp as were sport species by channel catfish and white bass.

Revetted Littoral (Table 6.3-20 and 6.3-21)

Like the natural littoral habitat, benthos of the revetted littoral zone was dominated by Oligochaeta. However, overall diversity was somewhat greater due to the presence of Hexagenia spp. and Sphaeriidae, as well as typical chironomid assemblages. Oligochaetes comprised 75 to 80 percent of the total benthos.

Density values ranged from 0 to $4,592/m^2$ during the study, with seasonal average densities of $764/m^2$ at Clarksville; $1,866/m^2$ at Winfield; $366/m^2$ at Ste. Genevieve; and $661/m^2$ at Cape Girardeau.

Diversity ranged from 0.0 to 1.55 in samples collected during the study, with composite diversities and evenness values of 2.06 and 1.67 at Clarksville, 1.42 and 1.11 at Winfield, 0.97 and 3.22 at Ste. Genevieve, and 0.83 and 1.19 at Cape Girardeau.

Average density, diversity, and evenness values were 1,315/m^2, 1.74, and 1.39, respectively, for the pooled river and 847/m^2, 0.90, and 2.20 for the open river.

Overall density, diversity, and evenness values were 699/m^2, 1.32, and 1.80, respectively. Therefore, the revetted littoral zone is one of the less productive habitat types and supports one of the lower overall diversities. It should be noted, however, that only the soft substrates of the revetted littoral area were sampled. The riprap itself, the dominant substrate in the habitat, was not sampled due to gear limitations. Evenness values were generally above average, indicating a more stable community and a diversity of available substrates.

Study results indicated that the revetted littoral was less productive than the natural littoral habitat; however, the overall benthic diversity was greater in the revetted littoral. The soft substrates of the natural littoral habitat generally do not support a diverse benthos, but the Oligochaeta and Chironomidae populations which frequently dominate this zone can reach extremely high densities. The rock riprap of the revetted littoral supported lower densities.

Fish--Data collected in the revetted littoral habitat indicated a fishery different from that of the natural littoral habitat. Results probably differ because seining was not conducted in the revetted littoral habitat. Dominant species were gizzard shad (9 and 57 percent), carp (41 and 15 percent), and freshwater drum (23 and 11 percent). In the pooled river, channel catfish (13 percent) and white bass (3 percent) were common and, in the open river, goldeye (6 percent) and flathead catfish (3 percent) were common. The absence of the shiner as a dominant taxon reflects the absence of seining data. However, young-of-the-year channel catfish, flathead catfish, goldeye, and gizzard shad were collected at the revetted littoral habitat.

Composite diversity and evenness values for the four sampling sites were 2.51 and 1.96 at Clarksville, 2.37 and 2.02 at Winfield, [illegible] and 1.21 at Ste. Genevieve, and 2.64 and 2.24 at Cape Girardeau. Average diversity for the pooled river was 2.44 and 1.93 for the open river. The overall average diversity was 2.18. Evenness averaged 1.99 for the pooled river, 1.72 for the open river, and 1.86 overall. In most cases, diversity averages were below the average values for all habitats.

Fish were collected only by electrofishing. CPE values of 47.4 and 63.7 were obtained for the pooled and open river, respectively. Both were above average and indicate the effectiveness of electrofishing in littoral habitats. CPE electrofishing values for each revetted littoral site were Clarksville (43.0), Winfield (51.8), Ste. Genevieve (102.4), and Cape Girardeau (25.0).

Commercial and forage fish categories were most abundantly represented. Carp and freshwater drum were the dominant commercial species, with gizzard shad as the dominant forage species. The channel catfish was the dominant sport species, with white bass and flathead catfish also among the more common sport species.

Species associations for the revetted littoral habitat include channel catfish in the pooled river, goldeye in the open river, and freshwater drum in both pooled and open river.

The lower than average diversity values may indicate relatively lower suitability for fish fauna, but may also reflect the fact that only one sampling method was used. However, CPE (electrofishing) values at the Ste. Genevieve site were higher than those at the Cape Girardeau site, and most other open river habitats.

Factors influencing the fishery of the revetted littoral habitat include reduced current conditions, uniform substrates, lack of cover, as well

as the use of rock riprap as a substrate for colonization by benthic invertebrates.

PILE DIKE

The previous characterization of habitat features for the stone dike field apply equally well to the pile dike habitat. However, this habitat is uncommon due to the few remaining pile dikes and their usual isolation within a stone dike field.

The pile dikes generally do not influence currents and substrate to the degree of stone dikes because of their generally decayed condition and lesser extension into the river. Potential fish cover and substrates for invertebrate colonization are provided by 1) the piles themselves, 2) the holes formed by scour around the piles, and 3) accumulated debris.

Benthic Invertebrates (Table 6.3-22)

Samples collected from the vicinity of pile dikes yielded primarily Oligochaeta, averaging 79 percent of the total organisms collected. Ephemeroptera, notably *Hexagenia* spp., were also common as were chironomids. Fingernail clams also were collected.

Density values ranged from 14 to $804/m^2$ in the samples collected with an average density of $153/m^2$ for Ste. Genevieve and $459/m^2$ for Cape Girardeau.

Diversity values ranged from 0.00 to 2.29 during the study with a composite diversity of 2.27 for Ste. Genevieve and 0.62 for Cape Girardeau. Respective composite evenness values were 1.69 and 0.78.

Overall average density, diversity, and evenness for the pile dike habitat were $306/m^2$, 1.45, and 1.71 respectively. This was the lowest overall density determined for any habitat and the diversity is comparatively midrange.

The lower productivity of the pile dike in comparison to the stone dike is evident and is likely due to 1) deteriorated condition of the pile dikes, and 2) much lower quantity of surface area and zone of effects provided by the pile dike. Also, the pile dikes generally are isolated or singular and cannot have the effect of a stone dike field on surrounding habitats and biota.

<u>Fish</u>

Pile dikes were sampled only in the open river reach. In all cases, only one or two pile dikes were available in each of the two sampling areas and most of these have sharply deteriorated from their original conditions. Dominant fish species were gizzard shad (32 percent), goldeye (30 percent), carp (13 percent), river carpsucker (5 percent), and mooneye (4 percent).

Composite diversity at Ste. Genevieve was 1.82 and at Cape Girardeau 2.27. Average open river and overall diversity was 2.05. These values were close to the average for all habitats. Composite evenness values were 2.33 at Ste. Genevieve, 2.27 at Cape Girardeau, and 2.30 overall.

Fish were collected by electrofishing, trammel netting, and gill netting, resulting in average CPE values of 21 for electrofishing, 0.7 for trammel netting, and 10 for gill netting. These values were below the average values combining all habitats. CPE values at Ste. Genevieve and Cape Girardeau respectively were, electrofishing (15.0, 27.0), trammel netting (0.5, 1.0), and gill netting (10.0, 0).

The commercial fish category was the most abundantly represented category, with carp and river carpsucker being the most abundant species. The dominant forage species was the gizzard shad. Goldeye and mooneye were the dominant representatives of the predatory nonsport-or-commercial category.

Overall, the pile dike habitat has a lower fishery value compared to other habitats. This is likely due to the deterioration of pile dikes and their limited physical effect on their surroundings. The few remaining pile dikes and their reduced extension also lessen their value as fishery habitat.

However, the pile dike does provide fishery habitat, and the goldeye and shortnose gar are notably associated with the pile dike habitat.

Bertrand and Garver (1973) sampled a pile dike near Chester, Illinois. Blue catfish were closely associated with this habitat. Carp, blue catfish, shortnose gar, and gizzard shad were the most abundant species (in decreasing order) collected. Flathead and channel catfish were the only other sport species collected.

MOUTH OF TRIBUTARY

The point or area in which tributaries enter the Mississippi River provides a transitional habitat in terms of faunal associations and characteristics. Key habitat features include reduced current velocities, relatively stable substrates, generally good cover conditions, and a variety of depths and substrate types. The tributary streams often provide key life history or natural history roles, such as serving as spawning habitats and providing refuge from main river conditions and high flows. Faunal species not commonly associated with larger rivers can be found on a limited basis in the tributary streams.

Benthic Invertebrates (Table 6.3-23)

Benthic invertebrates were not collected in this habitat.

Fish

Fish were collected by electrofishing and hoop netting. Gizzard shad dominated the catch (64 percent) followed by carp (10 percent), shortnose gar (5 percent), white bass (4 percent), and freshwater drum (4 percent).

Average diversity was 1.99 and average evenness 1.62. Catch-per-unit effort averaged 48 for electrofishing and 6.1 for hoop netting. No significant difference in catch-per-effort (CPE) was noted between the two tributary mouths sampled. CPE values at Ste. Genevieve and Cape Girardeau, respectively, were electrofishing (55.6 and 40.5) and hoop netting (1.7 and 10.6).

Forage and commercial fish species made up the bulk of the fish collected at the tributary mouth.

Gizzard shad was the most common forage species. Carp and freshwater drum were the dominant commercial species. White bass, channel catfish, bluegill, and white crappie were the most common sport species collected.

Table 6.3-1. Biotic and Physical Characteristics of the Tailwater Habitat—Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES			Gizzard shad	62
			Carp	11
			Freshwater drum	5
			White bass	5
DENSITY avg (range)				
TOTAL COLLECTED			1,210	
CATCH/EFFORT (avg)				
Electrofishing				63.5
Trammel net				0.9
Gill net				86.5
Hoop net				—
Frame net				—
Trawl				—
Seine				—
DIVERSITY* avg (range)	Evenness avg (range)		Diversity	Evenness
Total†			2.35 (1.69-3.02)	1.74 (1.28-2.19)
Partial**				
SUBSTRATE			Rock, sand, gravel, some silt near shore	
COVER			Stumps, logs	
CURRENT			0.5-5 fps	
DEPTH			1-9 m	
PERCENT OF AQUATIC HABITAT			1%	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.

Source: ESE, 1982.

Table 6.3-2. Biotic and Physical Characteristics of the Navigation Pool Habitat—Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta	(TM)†† 68	Gizzard shad	45
	Coelotanypus spp.	(TM) 9	Carp	10
	Cryptochironomus	(T) 5	Freshwater drum	9
	Hexagenia limbata	(I) 2	Shortnose gar	6
	Polypedilum spp.	(M) 2	Smallmouth buffalo	5
			YOY green sunfish and largemouth bass (present)	
DENSITY avg (range)	1,069/m² (14-2698/m²)			
TOTAL COLLECTED			1,750	
CATCH/EFFORT (avg)				
Electrofishing				44.1
Trammel net				—
Gill net				44.3
Hoop net				—
Frame net				24.5
Trawl				—
Seine				—
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	1.93 (0-2.39)	1.41 (0-2.15)	3.03 (2.70-3.37)	1.74 (1.20-[illegible])
Partial**	3.28			
SUBSTRATE			Silt-mud	
COVER			Stumps, some vegetation	
CURRENT			Spatially variable; 0-2.5 fps; faster nearer lock and dam	
DEPTH			1-5 m	
PERCENT OF AQUATIC HABITAT			7%	

* Shannon Weaver
† Includes all organisms.
** For benthos only, excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: [illegible], 1982.

Table 6.3-3. Biotic and Physical Characteristics of the River Lake Habitat—Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (TM)††	63	Gizzard shad	21
	Ceratopogonidae (TM)	7	Black bullhead	18
	Chironomus riparius (T)	7	Bluegill	16
	Procladius culiciformis (TM)	3	Black crappie	13
	Chironomus decorus (TM)	3	Carp	12
			YOY green sunfish, bluegill, largemouth bass, crappie, black bullhead, and carp (present)	
DENSITY (avg)	1,503/m^2 (488-2856)			
TOTAL COLLECTED			2,980	
CATCH/EFFORT (avg)				
Electrofishing				[illegible]
Trammel net				—
Gill net				131.3
Hoop net				—
Frame net				35.9
Trawl				—
Seine				—
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	2.14 (0.53-2.61)	1.66 (1.11-2.50)	2.75 (2.45-3.06)	2.04 (1.95-2.14)
Partial**	3.38			
SUBSTRATE			Soft silt-mud, detritus	
COVER			Vegetaton, some stumps and logs	
CURRENT			Typically none	
DEPTH			1-3 m	
PERCENT OF AQUATIC HABITAT			7%	

* Shannon Weaver

† Includes all organisms.

** For benthos only; excludes oligochaetes.

†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973).

Source: ESE, 1982.

Table 6.3-4. Biotic and Physical Characteristics of the Slough—Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligocheeta (TM)††	73	Gizzard shad	40
	Chironomus riparius (T)	12	Bluegill	10
	Chironomus plumosus (T)	6	Shortnose gar	10
	Ceratopogonidae (TM)	1	Carp	8
	Cryptochironomus (T)	1	Smallmouth buffalo	5
			YOY bluegill and river carpsucker (present)	
DENSITY (avg)	$1,980/m^2$ (172–2856)			
TOTAL COLLECTED			1,122	
CATCH/EFFORT (avg)				
Electrofishing				86.0
Trammel net				—
Gill net				59.3
Hoop net				—
Frame net				23.9
Trawl				—
Seine				—
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	1.46 (0.25–1.86)	1.21 (0.36–2.49)	2.86 (2.69–3.03)	2.12 (2.07–2.17)
Partial**	2.34			
SUBSTRATE			Soft silt-mud, detritus	
COVER			Logs, stumps, vegetation	
CURRENT			Typically none	
DEPTH			Typically <1m, depending on water level regulatory regime	
PERCENT OF AQUATIC HABITAT			7%	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant ([illegible])

Source: ERR, 1982.

Table 6.3-5. Biotic and Physical Characteristics of the Downstream End of Island--Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (TM)††	87	Gizzard shad	44
	Hexagenia limbata (I)	3	Carp	12
	Cryptochironomus spp. (T)	2	Shortnose gar	9
	Hexagenia spp. (MI)	2	Freshwater drum	5
	Chironomus riparius (T)	1	River carpsucker	4
			YOY green sunfish and largemouth bass (present)	
DENSITY (avg)	1,481/m^2 (14-3803)			
TOTAL COLLECTED			732	
CATCH/EFFORT (avg)				
Electrofishing				17.9
Trammel net				—
Gill net				33.7
Hoop net				—
Frame net				7.3
Trawl				—
Seine				—
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	1.11 (0-1.97)	1.07 (0-2.33)	3.07 (3.25-2.88)	2.13 (1.99-2.27)
Partial**	2.83			
SUBSTRATE			Silt-mud, sand	
COVER			Stumps, logs, vegetation	
CURRENT			0-3 fps	
DEPTH			1-3 m	
PERCENT OF AQUATIC HABITAT				

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: ESE, 1982.

Table 6.3-6. Biotic and Physical Characteristics of the Dike Field (Stone) Habitat—Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	71	Carp	28
	Hexagenia limbata (I)	5	Gizzard shad	20
	Cryptochironomus spp. (T)	4	Freshwater drum	16
	Musculium spp. (T)	3	Smallmouth buffalo	5
	Potamyia flava (M)	3	Channel catfish	4
DENSITY (avg)	1,177/m² (287-2727)			
TOTAL COLLECTED			635	
CATCH/EFFORT (avg)				
Electrofishing				29.7
Trammel net				1.8
Gill net				4.7
Hoop net				1.1
Frame net				—
Trawl				—
Seine				—
DIVERSITY*	avg (range)	Evenness avg (range)	Diversity	Evenness
Total†	1.98 (0.43-3.00)	1.48 (1.15-2.52)	3.15 (3.03-3.27)	2.36 (2.[illegible]-2.47)**
Partial**	3.53			
SUBSTRATE			Variable; silt-sand, rock riprap	
COVER			Logs, snags	
CURRENT			0-3.1 fps	
DEPTH			1-6 m	
PERCENT OF AQUATIC HABITAT			—	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: ESE, 1982.

Table 6.3-7. Biotic and Physical Characteristics of the Dike Field (Stone) Habitat—Open River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (TM)††	58	Carp	49
	Pentagenia vittigera (I)	16	Gizzard shad	26
	Hexagenia limbata (I)	15	Freshwater drum	8
	Cryptochironomus spp. (T)	3.4	White bass	3
	Hexagenia spp. (MI)	2.6	Channel catfish	3
DENSITY (avg)	$263/m^2$ (14-517)			
TOTAL COLLECTED			819	
CATCH/EFFORT (avg)				
Electrofishing				95.7
Trammel net				0.5
Gill net				6.0
Hoop net				0.7
Frame net				—
Trawl				—
Seine				—
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	1.64 (0-1.94)	1.86 (0-3.22)	2.26 (2.18-2.33)	1.78 (1.70-1.86)
Partial**	2.08			
SUBSTRATE			Silt-sand, rock riprap, debris	
COVER			Snags, logs, debris	
CURRENT			0-4.5 fps	
DEPTH			1-6 m	
PERCENT OF AQUATIC HABITAT			—	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: ESE, 1982.

Table 6.3-8. Biotic and Physical Characteristics of the Main Channel Habitat—Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES			Channel catfish (YOY)	45
			Speckled chub	34
			Shovelnose sturgeon	8
			Freshwater drum (YOY)	6
DENSITY (avg)				
TOTAL COLLECTED			53	
CATCH/EFFORT (avg)				
Electrofishing				—
Trammel net				—
Gill net				—
Hoop net				—
Frame net				—
Trawl				1.2
Seine				—
DIVERSITY* avg (range)			Diversity	Evenness
Total†			1.71 (1.52-1.90)	2.44 (2.17-2.72)
Partial**				
SUBSTRATE			Sand-gravel	
COVER			Typically none; isolated stumps and logs	
CURRENT			0.7-4.5 fps	
DEPTH			3-9 m	
PERCENT OF AQUATIC HABITAT			18%	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.

Source: HRS, 1982.

Table 6.3-9. Biotic and Physical Characteristics of the Main Channel Habitat—Open River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES			Gizzard shad	63
			Channel catfish (YOY)	25
			Bigmouth buffalo	12
DENSITY (avg)				
TOTAL COLLECTED			8	
CATCH/EFFORT (avg)				
Electrofishing				—
Trammel net				—
Gill net				—
Hoop net				—
Frame net				—
Trawl				0.9
Seine				—
DIVERSITY* avg (range)			Diversity	Evenness
Total†			0.63 (0–1.25)	1.31 (0–2.62)
Partial**				
SUBSTRATE			Sand-gravel	
COVER			Typically none	
CURRENT			3–6 fps	
DEPTH			5–17 m	
PERCENT OF AQUATIC HABITAT			40%	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.

Source: ESE, 1982.

Table 6.3-10. Biotic and Physical Characteristics of the Outside Bend Habitat—Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (TM)††	69	Gizzard shad	35
	Hexagenia limbata (I)	13	Freshwater drum	19
	Hexagenia spp. (MI)	4	Carp	12
	Cryptochironomus spp. (T)	4	Shortnose gar	7
	Sphaeriidae (F)	2	Channel catfish	6
			Flathead catfish	6
			YOY flathead catfish (present)	
DENSITY (avg)	1,299/m^2 (301-3544)			
TOTAL COLLECTED			567	
CATCH/EFFORT (avg)				
Electrofishing				38.8
Trammel net				0.0
Gill net				13.5
Hoop net				1.0
Frame net				—
Trawl				—
Seine				—
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	1.49 (0-2.15)	1.24 (0-2.97)	2.73 (2.52-2.93)	2.20 (2.01-2.38)
Partial**	2.58			
SUBSTRATE			Variable; sand-gravel, some silt	
COVER			Snags, logs	
CURRENT			0.1-3.8 fps	
DEPTH			1-8 m	
PERCENT OF AQUATIC HABITAT			3%	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant ([illegible], [illegible])

Source: ESE, 1982.

Table 6.3-11. Biotic and Physical Characteristics of the Outside Bend Habitat—Open River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	83	Gizzard shad	55
	Potamyia flava (M)	3.3	Carp	12
	Baetis spp. (I)	2.6	Goldeye	8
	Pentagenia vittigera (I)	1.8	Freshwater drum	8
	Argia spp. (I)	1.8	Flathead catfish	4
DENSITY (avg)	$135/m^2$ (43-359)			
TOTAL COLLECTED			392	
CATCH/EFFORT				
Electrofishing				25.0
Trammel net				0.1
Gill net				0.5
Hoop net				0.3
Frame net				—
Trawl				—
Seine				—

DIVERSITY*	avg (range)	Evenness avg (range)	Diversity	Evenness
Total†	1.23 (0-1.54)	1.50 (0-3.23)	1.85 (0.60-3.01)	1.58 (0.61-2.56)
Partial**	2.12			

SUBSTRATE	Silt-sand, some rock
COVER	Snags, logs
CURRENT	3-6 fps
DEPTH	1-6 m
PERCENT OF AQUATIC HABITAT	4%

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant ([illegible], [illegible]).

Source: [illegible], 1982.

Table 6.3-12. Biotic and Physical Characteristics of the Inside Bend Habitat—[illegible] River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	78	Sauger	30
	Potamyia flava (MI)	6	Freshwater drum	21
	Cryptochironomus spp. (T)	2	Gizzard shad	20
	[illegible] spp. (T)	2	Channel catfish	7
	Hexagenia spp. (MI)	1	Flathead catfish	5
			YOY flathead catfish (present)	
DENSITY (avg)	$1,277/m^2$ (273–2683)			
TOTAL COLLECTED			540	
CATCH/EFFORT				
Electrofishing				33.6
Trammel net				0.2
Gill net				0.5
Hoop net				0.9
Frame net				—
Trawl				—
Seine				—

DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	1.41 (0.29–2.73)	1.08 (0.41–3.07)	2.74 (2.72–2.76)	2.20 (2.2[illegible]–2.2[illegible])
Partial**	3.40			

SUBSTRATE	Variable; silt-clay, detritus
COVER	Stumps, snags, logs
CURRENT	0.1–3.0 fps
DEPTH	1–6 m
PERCENT OF AQUATIC HABITAT	[illegible]%

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: [illegible], 1982.

Table 6.3-13. Biotic and Physical Characteristics of the Inside Bend Habitat—Open River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	87.9	Gizzard shad	32
	Hexagenia limbata (I)	2.2	Goldeye	23
	Caenis spp. (MI)	2.2	Flathead catfish	15
	Ceratopogonidae (TM)	2.2	Freshwater drum	9
	Hydropsychidae (MI)	1.6	Shorthead redhorse	4
DENSITY (avg)	$157/m^2$ (14–775)			
TOTAL COLLECTED			228	
CATCH/EFFORT				
Electrofishing				10.3
Trammel net				0.2
Gill net				31.0
Hoop net				0.8
Frame net				—
Trawl				—
Seine				—
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	0.79 (0–1.21)	1.30 (0–2.54)	2.51 (2.11–2.92)	2.22 (0–2.62)
Partial**	1.23			
SUBSTRATE			Silt-sand	
COVER			Snags, logs	
CURRENT			1–3 fps	
DEPTH			1–5 m	
PERCENT OF AQUATIC HABITAT			5%	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973).

Source: ERE, 1982.

Table 6.3-14. Biotic and Physical Characteristics of the Straight-Stretch Habitat—Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	88	Gizzard shad	23
	Potamyia flagmata (M)	2	Carp	21
	Cryptochironomus spp. (T)	2	Freshwater drum	18
	Pentagenia vittigera (I)	2	Channel catfish	8
	Hexagenia limbata (I)	1	Shortnose gar	6
DENSITY (avg)	1,098/m^2 (29-2597)			
TOTAL COLLECTED			632	
CATCH/EFFORT				
Electrofishing				32.3
Trammel net				0.9
Gill net				2.0
Hoop net				1.5
Frame net				—
Trawl				—
Seine				—
DIVERSITY*	avg (range)	Evenness avg (range)	Diversity	Evenness
Total†	1.63 (0-2.50)	1.27 (0-3.22)	3.09 (2.88-3.29)	2.40 (2.39-2.42)
Partial**	3.58			
SUBSTRATE			Sand-gravel midriver; silt-mud, detritus nearer shore	
COVER			Variable; stumps, snags, logs	
CURRENT			0.1-3.8 fps	
DEPTH			1-8 m	
PERCENT OF AQUATIC HABITAT			33%	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: ESE, 1982.

Table 6.3-15. Biotic and Physical Characteristics of the Straight Stretch Habitat—Open River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	78	Gizzard shad	65
	Ceratopogonidae (TM)	6.7	Goldeye	10
	Micropsecta spp. (MI)	3	Carp	7
			Freshwater drum	5
			Flathead catfish	3
DENSITY (avg)	$103/m^2$ (0-359)			
TOTAL COLLECTED			1,003	
CATCH/EFFORT				
Electrofishing				50.1
Trammel net				0.1
Gill net				6.0
Hoop net				1.4
Frame net				—
Trawl				—
Seine				—

DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	1.30 (0-2.06)	1.64 (0-2.97)	1.91 (1.20-2.81)	1.50 (0.96-2.06)
Partial**	1.18			

SUBSTRATE	Silt-clay, some sand and rock
COVER	Snags, logs
CURRENT	2-5 fps
DEPTH	1-6 m
PERCENT OF AQUATIC HABITAT	42%

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, [illegible]

Source: [illegible], 1982.

Table 6.3-16. Biotic and Physical Characteristics of the Side Channel Habitat—Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	65	Carp	48
	Chironomidae (TM)	6	Gizzard shad	14
	Ephemeridae (I)	6	Channel catfish	9
	Hexagenia limbata (I)	5	Freshwater drum	7
	Ceratopogonidae (TM)	4	Shortnose gar	3
DENSITY (avg)	489/m^2 (14-861)			
TOTAL COLLECTED			352	
CATCH/EFFORT				
Electrofishing				25.7
Trammel net				0.4
Gill net				1.3
Hoop net				—
Frame net				—
Trawl				—
Seine				—
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	1.99 (0-2.27)	1.80 (0-3.23)	2.55 (2.37-2.72)	2.02 (1.97-2.06)
Partial**	2.98			
SUBSTRATE			Silt-mud, some sand	
COVER			Stumps, snags, logs, limited vegetation	
CURRENT			0.2-1.4 fps	
DEPTH			1-5 m	
PERCENT OF AQUATIC HABITAT			23%	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: ESE, 1982.

Table 6.3-17. Biotic and Physical Characteristics of the Side Channel Habitat—Open River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	83	Gizzard shad	56
	Polypedilum spp. (MI)	5.6	Carp	13
	Chironomus riparius (T)	3.4	Shortnose gar	11
	Cryptochironomus spp. (T)	2.4	River carpsucker	3
			Freshwater drum	3
DENSITY (avg)	787/m^2 (14-2655)			
TOTAL COLLECTED			738 (27,548 via chemofishing)	
CATCH/EFFORT				
Electrofishing				55.3
Trammel net				1.3
Gill net				29.0
Hoop net				1.1
Frame net				—
Trawl				—
Seine				—

DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	1.02 (0-1.94)	1.00 (0-3.22)	2.37 (1.49-2.95)	1.68 (1.19-2.17)
Partial**	2.58		Chemofishing	
			1.09	0.70

SUBSTRATE	Silt-sand
COVER	Snags, logs, vegetation
CURRENT	0.2-1.5 fps
DEPTH	1-50 m
PERCENT OF AQUATIC HABITAT	10%

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: ESE, 1982.

Table 6.3-18. Biotic and Physical Characteristics of the Natural Littoral Habitat—Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	96	Emerald shiner	44
	Ceratopogonidae (TM)	0.75	River shiner	23
	Cryptochironomus spp. (T)	0.68	Channel catfish	6
	Sphaeriidae (T)	0.33	Carp	6
	Chironomus riparius (T)	0.33	Gizzard shad	5
			Numerous YOY species (present)	
DENSITY (avg)	$2,149/m^2$ (301-6486)			
TOTAL COLLECTED			3,309	
CATCH/EFFORT				
Electrofishing				29.1
Trammel net				—
Gill net				—
Hoop net				—
Frame net				—
Trawl				—
Seine				280.7

DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	0.35 (0-0.99)	0.38 (0-1.27)	2.64 (2.15-3.12)	1.72 (1.43-2.00)
Partial**	2.56			
SUBSTRATE			Silt, some sand and mud	
COVER			Snags, stumps, logs	
CURRENT			0.2-2.5 fps	
DEPTH			0-3 m	
PERCENT OF AQUATIC HABITAT			—	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: ESE, 1982.

Table 6.3-19. Biotic and Physical Characteristics of the Natural Littoral Habitat—Open River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	88	Gizzard shad	45
	Cryptochironomus spp. (T)	4.2	Emerald shiner	33
			River shiner	6
			Channel catfish	3
			Numerous YOY species (present)	
DENSITY (avg)	$129/m^2$ (0-761)			
TOTAL COLLECTED			2,551	
CATCH/EFFORT				
Electrofishing				19.5
Trammel net				—
Gill net				—
Hoop net				—
Frame net				—
Trawl				—
Seine				170.3
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	0.82 (0-1.11)	1.36 (0-1.84)	2.14 (2.05-2.22)	1.56 (1.53-1.60)
Partial**	1.45			
SUBSTRATE			Silt-sand, some detritus	
COVER			Snags, logs, vegetation	
CURRENT			0.3-3 fps	
DEPTH			1-4 m	
PERCENT OF AQUATIC HABITAT			—	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: ESE, 1982.

Table 6.3-20. Biotic and Physical Characteristics of the Revetted Littoral Habitat--Pooled River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	75	Carp	41
	Hexagenia limbata (I)	7.5	Freshwater drum	23
	Cryptochironomus spp. (T)	2.7	Channel catfish	13
	Sphaeriidae (T)	2.3	Gizzard shad	9
	Musculium spp. (T)	1.7	White bass	3
			YOY channel catfish, flathead catfish, and gizzard shad (present)	
DENSITY (avg)	$1,315/m^2$ (172-4592)			
TOTAL COLLECTED			757	
CATCH/EFFORT				
Electrofishing				47.4
Trammel net				—
Gill net				—
Hoop net				—
Frame net				—
Trawl				—
Seine				—
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	1.74 (0.28-1.55)	1.39 (0.59-2.27)	2.44 (2.37-2.51)	1.99 (1.96-2.02)
Partial**	3.28			
SUBSTRATE			Rock riprap, some silt-sand	
COVER			Typically limited, some vegetation	
CURRENT			0.5-3.0 fps	
DEPTH			2-6 m	
PERCENT OF AQUATIC HABITAT			—	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: ESE, 1982.

Table 6.3-21. Biotic and Physical Characteristics of the Revetted Littoral Habitat--Open River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	80	Gizzard shad	57
	Hexagenia limbata (I)	6.5	Carp	15
	Chironomidae (TM)	3.0	Freshwater drum	11
	Cryptochironomus spp. (T)	3.0	Goldeye	6
			Flathead catfish	3
			YOY goldeye and channel catfish (present)	
DENSITY (avg)	$84/m^2$ (0-387)			
TOTAL COLLECTED			1,259	
CATCH/EFFORT				
Electrofishing				63.7
Trammel net				—
Gill net				—
Hoop net				—
Frame net				—
Trawl				—
Seine				—
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	0.90 (0-1.33)	2.20 (0-4.42)	1.93 (1.21-2.64)	1.72 (1.21-2.24)
Partial**	1.37			
SUBSTRATE			Rock riprap	
COVER			Typically none	
CURRENT			0.5-3.5 fps	
DEPTH			0-4 m	
PERCENT OF AQUATIC HABITAT			—	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973).

Source: ESE, 1982.

Table 6.3-22. Biotic and Physical Characteristics of the Pile Dike Habitat—Open River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES	Oligochaeta (T)††	79	Gizzard shad	32
	Hexagenia limbata (I)	6.5	Goldeye	30
	Cryptochironomus spp. (T)	2.3	Carp	13
	Sphaeriidae (T)	2.3	River carpsucker	5
			Mooneye	4
DENSITY (avg)	$306/m^2$ (14-646)			
TOTAL COLLECTED			115	
CATCH/EFFORT				
Electrofishing				21.0
Trammel net				0.7
Gill net				10.0
Hoop net				—
Frame net				—
Trawl				—
Seine				—
DIVERSITY* avg (range)		Evenness avg (range)	Diversity	Evenness
Total†	1.45 (0-2.29)	1.71 (0-3.12)	2.05 (1.82-2.27)	2.30 (2.27-2.33)
Partial**	2.33			
SUBSTRATE			Silt-sand, wood pilings	
COVER			Snags, logs, pilings	
CURRENT			0-2.5 fps	
DEPTH			1-4 m	
PERCENT OF AQUATIC HABITAT			—	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.
†† Pollution Tolerance: T=tolerant, M=moderately tolerant, I=intolerant (Weber, 1973)

Source: ESE, 1982.

Table 6.3-23. Biotic and Physical Characteristics of the Mouth of Tributary Habitat—Open River, GREAT III Reach

	Benthos	Occurrence (%)	Fish	Occurrence (%)
IMPORTANT SPECIES			Gizzard shad	54
			Carp	10
			Shortnose gar	5
			White bass	4
			Freshwater drum	4
DENSITY (avg)				
TOTAL COLLECTED			821	
CATCH/EFFORT				
Electrofishing				48.0
Trammel net				—
Gill net				—
Hoop net				6.1
Frame net				—
Trawl				—
Seine				—
DIVERSITY* avg (range)			Diversity	Evenness
Total†			1.99 (1.83-2.15)	1.62 (1.46-1.78)
Partial**				
SUBSTRATE			Soft silt-mud, detritus	
COVER			Snags, logs, vegetation	
CURRENT			0.2-2 fps	
DEPTH			1-5 m	
PERCENT OF AQUATIC HABITAT			<1%	

* Shannon Weaver
† Includes all organisms.
** For benthos only; excludes oligochaetes.

Source: ESE, 1982.

6.4 OVERALL COMPARISON OF HABITAT VALUES

BENTHIC COMMUNITIES

Benthic invertebrates are generally cyclic in population on an annual or seasonal basis. Benthic communities also are influenced by physical factors such as water temperature, dissolved oxygen, water depth, current conditions, and substrate type. Because of these trends and influences, the benthic populations sampled during the study varied with habitat and season. Although sampling efforts were not sufficiently extensive to allow strict qualifications and quantitative comparisons or strict analysis of trends, general comparisons of habitats and seasons have been made.

Diversity

The soft substrates of certain habitats consistently supported a greater diversity of benthic invertebrates during this study. In the pooled river sampling areas, river lakes, navigation pools, dike fields, and side channel habitats supported overall higher diversities of benthic invertebrates. Natural littoral zones, sloughs, and the downstream ends of islands supported overall lower diversities of benthic invertebrates.

In the open river sampling areas, dike field, side channel, and main channel border (outside and straight) habitats supported the higher overall diversities of benthic invertebrates. Natural and revetted littoral zones, and main channel borders (inside) supported the lower overall benthic diversities.

Overall, navigation pools, river lakes, and dike fields supported the higher benthic diversities. Evenness values were generally indicative of the habitat values indicated above.

Density

The soft substrates of habitats in the GREAT III study area supported different densities of benthic invertebrates during this study. On a seasonal basis, both diversity and density values varied with the habitat type considered. However, in reviewing overall data per habitat, certain habitats consistently yielded higher densities than other habitats.

In the pooled river sampling areas, downstream ends of islands, sloughs, river lakes, and natural littoral zones supported the higher overall densities of benthic invertebrates. Dike fields and side channels supported the lower overall densities. In the open river, side channels and dike fields supported the higher overall densities, whereas littoral zones and main channel border habitats supported the lower overall densities.

Overall, sloughs, river lakes, and the downstream ends of islands supported the higher densities of benthic invertebrates.

Benthic invertebrate data collected during this study suggest that those habitats affording reduced current speed, flow, and more stable substrates are more productive for benthic invertebrates.

Side channels, dike fields, littoral zones, and navigation pools all are characterized by quiet waters and more stable soft substrates. Dike fields also provide artificial substrates conducive to colonization by invertebrate organisms, thereby enhancing diversity and density. In the open river, higher benthic productivity and diversity were found in side channels and dike fields, as other habitats have strong currents and harder, more unstable substrates scoured by the current.

The least productive benthic habitats were generally those having swifter currents and scoured substrates, notably the main channel border habitats. Side channels in the pooled river supported an overall

benthos lower in diversity and abundance. This may be due to soft, flocculent substrates and water quality stresses likely to occur during periods of summer stagnation.

Ecological Sensitivity

Benthic invertebrate taxa demonstrate a wide range of ecological requirements and sensitivities to environmental conditions and stresses (Hynes, 1970; Weber, 1973). Certain taxa have been designated as indicators of good water quality and suitable environmental conditions, whereas others are considered indicative of degraded water quality and environmental conditions.

Table 6.4-1 provides information on life history features and ecological sensitivities of major benthic invertebrate taxa collected during the study. Table 6.4-2 rates the pollution tolerance of the taxa collected, according to information from Weber (1973).

The invertebrate taxa collected in this study are generally considered ecologically tolerant, or moderately tolerant, and adaptable to a wide range of environmental conditions. The dominant benthic groups, the Oligochaeta and Diptera are found in almost any body of water and aquatic habitat and are considered tolerant to moderately tolerant of water quality degradation (pollution).

Genera of the orders Ephemeroptera, Trichoptera, Odonata, Hemiptera, Trichoptera, and Coleoptera generally are considered moderately tolerant of water quality degradation. These genera are common in a wide range of freshwater aquatic habitats, but generally are more common in those habitats having at least some flowing water and firm substrates.

Several taxa considered strictly intolerant of pollution (Weber, 1973) were collected. These include: Hydracarina, *Baetis*, *Neureclipsis*, Leptoceridae, *Ablabesmyia*, *Chironomus tentans*, *Xenochironomus*, and *Truncilla truncata*. These taxa were generally not common in the study

area due in part to water quality degradations and in part to habitat unsuitability. The above information comes from several sources (Weber, 1973; Pennak, 1978; Hynes, 1970; and Merrit and Cummins, 1978).

The benthic invertebrate data collected suggest some relationships between habitat type and the ecological sensitivity of associated benthic invertebrates. The Oligochaeta and Diptera generally were found in all habitats sampled. Ephemeroptera were most common in littoral, dike field, and main channel border habitats. Odonata and Trichoptera were closely associated with dike field and main channel borders, with Trichoptera common in side channels. Since significant dissolved oxygen deficiencies are likely to occur only in backwater habitats, this would likely be one factor in the affinity of Trichoptera, Ephemeroptera, and Odonata for main river habitats and the dominance of Oligochaeta and Diptera in backwater habitats. Another factor would be the presence of stone dikes and revetted areas, which would be highly suitable substrates for colonization.

The above associations are primarily due to habitat characteristics including substrates and hydrological characteristics. Water quality conditions are not thought to vary significantly among habitat types, with the exception of localized differences in dissolved oxygen and water temperature.

FISH COMMUNITIES

The ichthyofaunal communities associated within the GREAT III reach of the Mississippi River represent a generally diverse and productive assemblage of fishes. The habitats sampled produced varying results in terms of species richness, diversity, and productivity. The data indicate that the importance of a particular habitat type may be variable with regard to site-specific characteristics. The data also indicate the overall relative importance of specific habitat types to the fisheries communities in the Mississippi River.

Habitats within the GREAT III study area which support the more diverse ichthyofaunal communities varied between pooled and open river areas. More diverse assemblages of fishes were found at the pooled sites in the dike field habitat, navigation pool, downstream-end-of-island, and main channel border-straight stretch habitats. Lower diversities were encountered in the main channel habitat. Variable diversities were noted at the remaining habitats with most values recorded ranging between 2.4 and 2.8, indicating moderately diverse fish communities.

Trends in the diversity at habitats in the open river were not clearcut. Habitats producing the higher diversity in the open river were main channel border-inside bend and side channel habitats. The main channel habitat reflected the lowest diversity (in part due to limited sampling success) while the remaining habitats produced diversity values generally less than 2.0.

The habitats producing higher diversity values in the pooled and open river sites were those habitats that generally contained greater microhabitat variety within each habitat. This microhabitat variety (currents, depths, bottom sediments, log snags, etc.), along with greater stability of these habitats, was probably the primary reason these habitats supported higher diversities. Habitats with little microhabitat variety and less stability, such as the main channel habitat, supported lower diversities of fish.

Evenness values were generally consistent with diversity values and indicated similar habitat values.

<u>Productivity of Fish Communities</u>

The abundance (catch/effort and percent abundance) data collected indicate that sites and habitats contain fish communities different in species composition and abundance. Some habitats and sites were more productive than others. Some habitats were particularly productive for one species or group of species.

The species associations found in the open river and pooled river probably were largely based upon current velocity and its associated physical parameters. The lentic associated species were most common in the pooled river due to the presence of navigation pools, sloughs, river lakes (habitats not found in the open river), and the slower currents found at most habitats throughout the pooled river. Conversely, the species collected most commonly in the open river were probably abundant due to the larger amounts of swift water habitat. In addition, construction of dams apparently has reduced the populations of blue catfish, skipjack herring, and possibly chestnut lamprey above St. Louis (Smith, 1979; Pflieger, 1975).

Certain species, such as carp and gizzard shad, were typically abundant in all habitats in both the open and pooled portions of the river. There were some indications, however, that carp were somewhat more abundant in reduced current areas. This assumption is based upon the greater abundance of carp at revetted littoral and stone dike habitats in the open river and side channel, littoral, river lake, navigation pool, and inside bend channel border habitats in the pooled river. The softer substrates associated with most of these habitats also may play a role in the distribution of carp.

Specific habitat associations, based upon samples collected during the study, are numerous. Habitat affinities similar at both pooled and open river locations include:

1. goldeye and mooneye collected most frequently along main channel border and dike habitats;
2. channel catfish at natural littoral habitats;
3. flathead catfish at main channel border and revetted littoral habitats; and
4. shorthead redhorse along main channel border habitats.

The species/habitat associations that were similar between the pooled river and open river are based on the fact that the habitats with which

these species are associated are similar in the two segments of the river. Littoral, dike field, and main channel border habitats are physically similar between the pooled and open river. Consequently, species adapted to these habitats are found in similar habitats at each site.

Species/habitat affinities that differed between pooled and open river sites were generally due to habitat availability. Species closely associated with river lakes, sloughs, and navigation pool habitats in the pooled river were either uncommon in the open river or were collected at habitats most similar to those in the pooled river (usually side channel and/or mouth of tributary habitat). These areas of the open river provide essential habitat similar to that in the pooled river habitats. However, this open river habitat generally is not as extensive and usually not as physically appropriate for the species associated with river lakes, sloughs, and navigation pools. Consequently, the abundance of these species in the open river was generally less than in the pooled river.

Study results also revealed the importance of specific habitat types to the different species present in the river. Based on collections, it is apparent that pooled river habitats such as river lakes, dike fields, navigation pools, sloughs, and littoral areas support more diverse and productive ichthyofaunal communities. The eutrophic state of habitats such as river lakes and sloughs plays an important role in the quality of the fish community present. Habitats such as these, which were highly filled with sediments and are therefore shallow in nature, were much less productive than those areas which have some moderate to deep water areas.

Examples showing the importance of eutrophic state are the slough and river lake habitats sampled at the Clarksville site. These habitats were very shallow due to heavy siltation and supported fish communities much less diverse and productive than the Winfield habitats, which were

not as eutrophic. Tailwaters and downstream end of island habitats also were important, particularly for species such as shovelnose sturgeon, sauger, white bass, and other fishes. Main channel border areas were somewhat less productive, but supported a varied assemblage of fishes including taxa such as goldeye, shorthead redhorse and catfish, which were not always abundant at other habitats. The main channel habitat apparently (based on limited data) supported fewer fishes than the other habitats during the study.

Data collected during this study substantiate data collected at the pooled river by Illinois Department of Conservation biologists, which revealed that river lakes, sloughs, tailwaters, side channels, and in some cases channel border areas are the more productive fishery habitats in the pooled river (Bertrand and Dunn, 1973; Bertrand and Lockart, 1973; and Dunham, 1971).

Open river habitats which supported the more diverse and productive assemblages of fishes include side channel, mouth of tributary, littoral and stone dike habitats. Studies by Bertrand and Allen (1973) and Bertrand and Garver (1973) also indicate the importance of side channel habitats in the open river. Other open river habitats appeared to be generally less productive, but site-specific influences may increase their productivity locally.

Biological Factors Influencing Habitat Utilization

Association of fish species with specific habitats is based upon more than abiotic physical factors. Biotic influences such as the appropriate food base, size and age of the fish, and spawning requirements also are involved in the establishment of ichthyofaunal assemblages at particular habitat types.

Collections of ichthyoplankton made during the study have indicated that larval densities are highest at littoral areas compared to main channel, navigation pool, and tailwater habitats. Fish larvae populations were

not sampled in other areas, such as side channels, sloughs, and river lakes. However, larval densities in these areas also are expected to be high (Hall, 1980; Gallagher and Connor, 1980).

The higher ichthyoplankton densities exhibited in the littoral areas (near shore) are typical of main river ichthyoplankton collections (Gallagher and Connor, 1980; Gill, 1981). These densities may be associated with general river currents, shoreline inputs from extrariver areas, shallow water spawning of most fish species (Smith, 1979; Pflieger, 1975), and the presence of larger amounts of "cover" along the littoral zone for larval and juvenile stages. It is likely that all of these factors combine to influence the distribution of larval fishes within the GREAT III study area.

In addition to the larval collections, seining samples made in natural littoral habitats at all collection sites indicate the importance of these areas as nursery habitats for young-of-the-year fishes of numerous species. Other habitats, including revetted littoral, side channel, navigation pool, dike field, slough, and river lake habitats, although not specifically sampled by seining for young-of-the-year fishes, also are expected to be important nursery sites.

Analyses of benthic macroinvertebrate samples collected concurrently with the ichthyofaunal surveys also provide information concerning the distribution of fishes between habitats. Pooled river benthic densities were highest at the littoral (revetted and natural) and slough habitats. Open river macroinvertebrate densities and diversities were highest at side channel and dike field habitats.

The habitats supporting the highest benthic densities at the pooled and open river sites were among those sites supporting the highest diversity and productivity of fishes. These habitats can support higher densities of fishes due to their higher macroinvertebrate densities. High macroinvertebrate densities and diversities are important due to the

fact that almost all fish species feed on macroinvertebrates during all or part of their life cycles (Hynes, 1970). Those fishes which are piscivorous in nature also may be attracted to areas of high benthic densities due to the presence of higher densities of prey fishes in those areas.

Based on adult fish, juvenile fish, ichthyoplankton, benthic macroinvertebrate, and historical data, it is apparent that abiotic and biotic factors influence the distribution of fish species and densities between habitat types. Physical factors such as substrate, current, and depth, influence both the benthic and ichthyofaunal communities. Additionally, the benthic community influences the fish community.

The habitats producing the highest densities and diversities of fishes at each site do sc for a number of reasons. Important reasons include the fact that these habitats supply the appropriate physical as well as biotic environment (in the form of an adequate food base) for the fish species collected at each habitat. Additionally, life cycle needs in the form of appropriate spawning habitats (abiotic), nursery habitats (biotic and abiotic), and larval habitats (primarily abiotic) play an important role in the associations of fishes to particular habitat types.

Collections of fishes, therefore, which indicate habitats such as littoral areas, side channels, sloughs, river lakes, dike fields, and navigation pools, as being more productive and diverse, are indicative of both physical and biological conditions. These habitats possess characteristics important to a variety of life history phases. Spawning needs and juvenile fish needs are satisfied in shallow water areas such as littoral and extrachannel areas. Additionally, these areas frequently contain higher densities of fish larvae during spawning periods for many fish species. Along with these factors is the more basic factor of food availability. The areas with the highest densities of macroinvertebrates also were among those highest in fish

productivity. It is apparent that life history needs, combined with the physical features of the habitats, influence the association of fishes to specific habitat types. The areas which satisfy the biotic and abiotic needs of a variety of fishes support the greatest abundance and variety of species.

Commercial and Sport Fishes

The fish species collected during the study were classified based upon their primary use within the GREAT III study area. Twenty sport species and nine commercial fish species were identified in the collections. The remaining species were placed into three categories which were forage (19 species), predatory non-sport or commercial (9 species), and omnivorous non-sport or commercial (5 species).

The commercial fishes collected were numerically dominated by carp in the sample collections. The other commercial species collected were freshwater drum, smallmouth buffalo, river carpsucker, bigmouth buffalo, quillback, highfin carpsucker, black buffalo, and grass carp, in order of decreasing abundance in the catch.

The data indicate a tendency for commercial fishes to be most abundant in electrofishing collections along the revetted littoral habitat. In less productive areas such as channel border areas, these fishes were also frequently more abundant than sport species, with the exception of catfishes.

The channel catfish was the most common sport species collected overall. Other relatively abundant sport species were bluegill, black bullhead, black crappie, white bass, flathead catfish, white crappie and largemouth bass in decreasing order of percent occurrence.

Sport fishes generally were more abundant in reduced current areas such as side channels, river lakes, navigation pools, sloughs and dike fields. Commercial fishes also were common in these areas. Predatory

non-sport or commercial and forage fishes also had highest production levels at these areas.

Commercial fish were generally less specific in their habitat requirements than were sport fishes, based upon collection data. These fishes were common in all habitats, although specific species within the commercial fish group showed different habitat affinities. Sport species generally had more restricted habitat affinities. Sport species typically were more abundant at the pooled river sites where appropriate habitat was more abundant. Commercial fishes (especially carp) were commonly found in all habitats. The abundance of commercial species in areas where other species are less common is not unusual. Carp and many other commercial species have less stringent habitat requirements than many sport fishes, and therefore fish are frequently the most abundant species in areas where the habitat requirements of other species are not met (Pflieger, 1975).

Young-of-the year fishes were collected at a variety of habitats. The natural littoral habitat produced the greatest number and variety of juvenile fishes, primarily due to the seining collections made at that habitat. Other habitats where collections provided a variety of juvenile fishes were the river lake and revetted littoral areas. Young-of-the-year fish species collected at a variety of habitats included channel catfish (main channel, natural littoral, revetted littoral, and side channel), green sunfish (navigation pool, river lake, downstream end of island, dike field, and natural littoral), and flathead catfish (revetted littoral, main channel border). The association of a variety of young-of-the-year fishes to the littoral, river lake, and other shallow water habitats is evidently due to the general shallow water spawning habits of most fish species, the reduced current, and generally more cover available at these habitats, making them important habitats for at least the juvenile portions of many fishes life cycles.

Tables 6.2-11 and 6.2-12 describe habitat associations of major species collected during the study. Of the commercial species, carp were common in all habitats but most abundant in revetted littoral and stone dike habitats. Freshwater drum were found commonly in most habitats, especially the main channel border, littoral, and side channel habitats. Buffalo were most commonly collected in river lake, slough, navigation pool, and side channel habitats. Carpsuckers exhibited no close habitat associations, being found in most habitats.

In general, sport species exhibited more defined habitat associations. Channel catfish were most abundantly collected in natural littoral habitats, but were common in dike field, side channel, and main channel border habitats. Crappies were closely associated with river lakes, sloughs and navigation pools in the pooled river and side channels and tributary mouths in the open river. Bluegill and bullheads were closely associated with river lake, navigation pool and slough habitats. Flathead catfish were most abundantly collected in the revetted littoral habitat but otherwise were similar to channel catfish in terms of habitat associations.

Threatened and Endangered Species

No species listed as threatened or endangered by the United States Fish and Wildlife Service or the states of Illinois or Missouri were collected during the investigations (Illinois Department of Conservation, 1979; Missouri Department of Conservation, 1978; Illinois Natural Land Institute, 1981).

However, several species were collected that are considered rare in the study area. These species were the brown bullhead, river redhorse, and western sand darter.

Two specimens of brown bullhead were collected at the Winfield river lake. This species is considered rare in the state of Missouri; however, the collections were made in Illinois. The species is not

abundant in Illinois or Missouri, although it is widely distributed in Illinois. Floodplain and glacial lakes, as well as swamps with abundant vegetation, are typical habitats for this species (Smith, 1979; Pflieger, 1975). Based upon its habitat requirements, it is not surprising that brown bullhead specimens were collected in the river lake habitat; it is probable that they may be found in other such habitats in the study area.

Specimens of river redhorse were collected at littoral areas at the Clarksville and Ste. Genevieve sites. This species is not abundant anywhere in Missouri or Illinois. It is most frequently collected in medium-sized streams with rock and gravel bottoms and strong permanent flow. The river redhorse is intolerant of silt bottoms, turbid water, and pollution (Smith, 1979; Pflieger, 1975). Consequently, this species is likely to remain uncommon in the GREAT III area of the Mississippi River.

Western sand darters were collected at the Winfield natural littoral habitat by seining and in the main channel habitat at Clarksville by trawling. This species is not abundant in either Illinois or Missouri. It is associated with pure sand habitats and is intolerant of turbidity, siltation, and strong currents. It is not known from the Mississippi River south of the mouth of the Missouri River (Pflieger, 1975; Smith, 1979). Based upon the western sand darter's ecological requirements, it is likely that this species is not abundant and is not likely to become abundant, except perhaps locally, in the GREAT III study area.

Although not collected during the present study, several threatened or endangered species that have historically occurred, or have the potential to occur, have been collected in the Mississippi River. These species include:

Lake sturgeon	(*Acipenser fulvescens*)
Pallid sturgeon	(*Scaphirhynchus albus*)
Alligator gar	(*Lepisosteus spatula*)

Alabama shad	(*Alosa alabamae*)
Sturgeon chub	(*Hybopsis gelida*)
Sicklefin chub	(*Hybopsis meeki*)
Burbot	(*Lota lota*)

(Smith, 1979; Pflieger, 1975).

The lake sturgeon, although rarely collected, was once common in the Mississippi River. It occurs in the Mississippi and other large rivers above the mouth of the Missouri River. Overfishing, siltation, pollution, dam construction, and habitat loss are all considered causes for its reduction from its former abundance (Smith, 1979; Pflieger, 1975).

The pallid sturgeon, like the lake sturgeon, is a large river species whose abundance has decreased due to dam construction and channel modification. It is found in the Missouri River and in the Mississippi River south of the Missouri River mouth (Smith, 1979; Pflieger, 1975). Pallid sturgeon were collected by Grace and Weithman (1982) in the vicinity of the Ste. Genevieve sampling area.

The Alabama shad is an anadromous species that enters fresh water to spawn. It has historically been recorded in the Mississippi River and its tributaries south of the Missouri River. Abundance apparently has decreased due to the construction of dams on many rivers. The adults are historically in the area to spawn only briefly before returning to the sea. Adults do not feed while in freshwater and the young-of-the-year migrate south after their first summer (Smith, 1979; Pflieger, 1975). Grace and Weithman (1982) also collected this species in their investigation of stone dike habitats near Ste. Genevieve.

Alligator gar apparently have always been rare in the GREAT III study area. They occur downstream from the mouth of the Missouri River and seem to prefer pools and other extra channel areas. The fish is large, frequently weighing over 100 pounds. Little is known of its life history or habitat requirements (Smith, 1979; Pflieger, 1975).

The sturgeon chub and sicklefin chub are small, open-channel dwelling species. They occur in the Mississippi River downstream of the Missouri River. They are tolerant of turbidity and are found over firm sand or gravel bottoms. Little is known of the life history of these species (Smith, 1979; Pflieger, 1975).

The burbot is occasionally reported in collections by commercial fishermen on the Mississippi River, especially above the confluence of the Missouri River. It is probably not a sustained part of the GREAT III fauna but occurs as occasional strays from further north (Pflieger, 1975; Smith, 1979).

It is evident from the literature data that the six threatened or endangered species potentially occurring in the study area are not commonly collected. They generally occur in only part of the study area (either above or below the mouth of the Missouri River) and are not likely to become abundant in the foreseeable future.

Table 6.4-1. Ecological Requirements and Associations of Major Invertebrate Taxa in the GREAT III Reach

Taxa	Ecological Requirements and Associations
Nematoda (Roundworms)	Nematodes are found in almost any aquatic habitat and body of water. They are one of the most tolerant and adaptable invertebrate groups. Food habitats are diverse, ranging from carnivorous predation to omnivorous bottom feeding. Nematodes are most abundant in soft substrates, especially where aquatic vegetation or detrital accumulations are present.
Oligochaeta (Worms)	Most common in soft substrates and organic detritus found in stagnant or sluggish waters; feeding consists of the ingestion of substrate matter and processing of its organic constituents; generally tolerant of environmental stress and often proliferate in areas receiving heavy organic inputs (sewage, for example).
Hirudinea (Leeches)	Most frequently found in shallow waters that provide cover, as well as in stable substrates; most leeches feed on body fluids of larger organisms, but some are scavengers or carnivores on smaller organisms; leeches are considered generally tolerant of environmental stress.
Hydracarina (Water Mites)	Water mites are most abundant in standing water habitats having aquatic macrophyte development. They are generally intolerant of water quality degradations. Feeding is primarily carnivorous or parasitic upon other aquatic invertebrates.
Isopoda (Aquatic Sowbugs)	Usually restricted to shallow waters with abundant cover in the form of rocks, vegetation, and debris; primarily scavengers but do feed on plant material; moderately sensitive to environmental stress.
Collembola (Springtails)	Collembolans are commonly found on the water surface in quiet water habitats. They feed on algae, vegetation, and detritus. Little information is available regarding pollution tolerance.

Table 6.4-1. Ecological Requirements and Associations of Major Invertebrate Taxa in the GREAT III Reach (Continued, Page 2 of 3)

Taxa	Ecological Requirements and Associations
Ephemeroptera (Mayflies)	Occupy almost any body of well-oxygenated water; they may be found in rocky riffles, burrowed into bottom silts and sands, or hidden within clumps of organic detritus; probably most abundant in rocky riffles; most are herbivorous; generally considered moderately tolerant to intolerant of environmental stresses.
Odonata (Dragonflies, Damselflies)	Order contains dragonflies and damselflies and, like the Ephemeroptera, the nymphs of this order are found in a wide variety of relatively clear waters; are carnivorous; and considered moderately tolerant to intolerant of environmental stress.
Trichoptera (Caddisflies)	Most abundant in gravel or small-rock riffles with extensive mats of algae; require an abundant oxygen supply and are generally restricted to shallow, relatively clear waters; considered moderately tolerant to intolerant of environmental stress.
Coleoptera (Beetles)	Major insect order containing aquatic adults as well as aquatic larvae; although the order is large and diverse, and aquatic forms occupy a variety of habitats, they are generally associated with calm water, clean substrates, and aquatic vegetation; however, some are most common in faster currents; larvae may be found in accumulations of organic detritus; most are carnivorous, but some are scavengers or herbivores; tolerance to environmental stresses is highly variable.
Hemiptera (True Bugs)	Composed of several diverse families and genera, some of which are aquatic only in the larval stage and others that are aquatic in all life stages; generally found in quiet, shallow waters with aquatic vegetation or abundant detritus; some occur in riffles, clinging to rocks or other solid substrates; may be present on the water surface, suspended just below the surface film, clinging to aquatic vegetation or detritus, or on solid bottom substrates; most are predatory upon other aquatic invertebrates or small fish.

Table 6.4-1. Ecological Requirements and Associations of Major Invertebrate Taxa in the GREAT III Reach (Continued, Page 3 of 3)

Taxa	Ecological Requirements and Associations
Diptera (Flies)	The most abundantly represented order in streams and lakes; found in almost every type of aquatic habitat; exhibit a great diversity in habitat association and life history; the family Tipulidae is commonly encountered in accumulations of organic detritus, upon which it feeds; the family Simulidae is usually found attached to rocks in riffle areas where it filters organic particles from the water; the family Chironomidae is most abundant in soft substrates, organic detritus, and upon aquatic vegetation and is primarily a herbivore or detritivore; the chaoboridae are characteristic of deeper, open water and soft substrates; are predaceous upon other invertebrates (the above families make up a majority of the Dipterans collected); order exhibits a wide variety of tolerance to environmental stresses but is often the most abundant order where stress is severe.
Gastropoda (Snails)	Most frequently collected in shallow water containing abundant vegetation; primarily herbivorous and require abundant dissolved oxygen, alkaline pH, and relatively hard, alkaline waters in order to thrive; given these water quality sensitivities, considered moderately tolerant to intolerant of environmental stresses.
Pelecypoda	Constitute part of the mollusc fauna; most abundant in shallow waters with stable sand or gravel substrates and devoid of [illegible]; feed by filtering microcrust[illegible] organic particles from the water; [illegible] with relatively unstressed ([illegible]) waters.

Sources: Pennak, 1978.
Weber, 1973.
Merritt and Cummins, 1978.

Table 6.4-2. Pollution Tolerance of Collected Benthic Invertebrate Taxa

Taxa	Pollution Tolerance*
Nematoda	M
Oligochaeta	M-T
Hirudinea	T
Hydracarina	I
Isopoda	
Asellus spp.	T-I
A. intermedius	M
Collembola	
Ephemeroptera	
Potamanthidae	
Potamanthus spp.	
Ephemeridae	
Hexagenia spp.	
H. limbata	
Pentagenia vittigera	
Ephemera spp.	
Caenidae	
Caenis spp.	M-I
Baetidae	
Baetis spp.	I
Heptageniidae	
Stenonema spp.	M-I
Odonata	
Gomphidae	
[illegible] spp.	[illegible]
Coenagrionidae	
Argia spp.	[illegible]
Hemiptera	
Corixidae	T

Table 6.4-2. Pollution Tolerance of Collected Benthic Invertebrate Taxa (Continued, Page 2 of 3)

Taxa	Pollution Tolerance*
Trichoptera	
Philopotamidae	
Neureclipsis spp.	I
Hydropsychidae	
Potamyia flava	M
Hydropsyche orris	M
Cheumatopsyche spp.	M
Leptoceridae	I
Ceraclea	
Coleoptera	
Elmidae	
Stenelmis spp.	M-I
Dubiraphia spp.	M
Hydrophilidae	
Berosus spp.	T
Diptera	
Chaoboridae	
Chaoborus spp.	M-I
Ceratopogonidae	T-M
Chironomidae	
Tanypodinae	
Pentaneurini	
Pentaneura spp.	T-I
P. flavifrons	T
P. monilis	
Procladius spp.	T-M
P. adumbratus	
Ablabesmyia spp.	I
Tanypus spp.	M
T. punctipennis	M
Coelotanypodini	
Coelotanypus spp.	T-I
C. concinnus	T-I
Chironominae	
Chironomini	
Chironomus spp.	T-I
C. riparius	T
C. militaris	

Table 6.4-2. Pollution Tolerance of Collected Benthic Invertebrate Taxa (Continued, Page 3 of 3)

Taxa	Pollution Tolerance*
C. decorys	
C. plumosus	T
C. tentans	I
C. cristatus	
Tendipes ferrineovittatus	
Xenochironomus spp.	I
Harnischia spp.	M-I
Robeckia claviger	
Cryptochironomus spp.	T-I
Parachironomus spp.	M
Paracladopelma spp.	
Glyptotendipes spp.	T
G. sensilis	
Polypedilum spp.	M-I
P. flavus	
Paralauterborniella spp.	
Dicrotendipes spp.	M-I
Limnochironomus spp.	
L. modestus	
Tanytarsini	
Tanytarsus spp.	M-I
Microspectra spp.	M-I
Orthocladinae	
Cricotopus spp.	M-I
Dolichopodidae	M
Empididae	
Cyclorrapha	
Gastropoda	
Campeloma spp.	M
Pelecypoda	
Unionidae	
Quadrula quadrula	M
Q. nodulata	M
Trunella truncata	I
Sphaeriidae	
Sphaerium spp.	M
Musculium spp.	T

* T-Tolerant; M-Moderately Tolerant (Facultative); I-Intolerant

Sources: ESE, 1982.
Weber, 1973

6.5 COMPARATIVE LITERATURE REVIEW

HABITAT CHANGES

Most quantitative analyses of aquatic habitat surface areas in the GREAT III reach of the Mississippi River have been limited to the pooled portion of the river. Concern over potential impacts caused by construction of locks and dams and other navigation aids have generated much interest in pooled river habitat areas. Although aquatic habitats in the open river also have been greatly influenced by navigation structures, they have not been inventoried as thoroughly as the pooled river habitats.

Habitats within specific portions of the open river have been described, (Emge et al., 1974 and Schramm and Lewis, 1974) and the geomorphic features of the river between St. Louis and Cairo have been analyzed (Simons et al., 1974). Johnson et al., (1975) summarized the effects of the 9-foot navigation channel on aquatic habitats in the Middle Mississippi River.

According to Rasmussen (1979), the open river is being reduced in width and most of the habitat types (except the main channel and main channel border) are being reduced in area. Sloughs and river lakes and ponds are scarce in the open river. Acreage measurements made for the present study of the GREAT III reach corroborate these statements. The main channel and main channel border habitats account for over 90 percent of the mapped area. Sloughs, river lakes, and ponds were scarce or absent and none were mapped. Extra-channel habitats have probably been reduced by a number of factors, primarily structural modifications for navigation and flood control purposes.

Hagen et al. (1977) mapped aquatic and terrestrial habitats in the floodplain of the Mississippi River from Cairo, Illinois to Guttenberg,

Iowa. The open water habitats mapped were main channel, side channel, lake, and pond. Waters supporting aquatic vegetation were also mapped. Total aquatic acreages measured by Hagen et al. (1977) for the open river are 17.4 percent larger than the total open river acreage measured for the present study (Table 5.1-1). Some of the variation identified is probably present because the two studies mapped different habitat types. A more likely cause of variation, however, is the fluctuation in water levels recorded on the individual data sources utilized in each study. Water levels and, therefore, water surface area can fluctuate greatly on the open river, as well as in the pooled river.

Sternberg (1971) mapped the Mississippi River above Lock and Dam 26. He identified several habitat types, but did not measure the areas of the habitats mapped. Colbert et al. (1974) evaluated the aquatic resources in Pools 24, 25, and 26 as part of the Corps of Engineers' inventory and assessment of the navigation pools (Solomon et al. 1975). Acreages of main channel, river border, side channel, dike field, and backwater habitats were measured. Yarbrough and Hensley (1980) also measured aquatic habitats in Pools 24, 25, and 26. They measured main channel, main channel border, side channels, sloughs, lakes and ponds, tailwaters, and marsh.

Not all habitats measured by Colbert et al. (1974), Yarbrough and Hensley (1980), and the present study are comparable, but several of the habitat areas are similar. According to Colbert et al. (1974) side channels made up 27 percent of the pooled river habitat. Side channels accounted for 24 percent and 23 percent of the aquatic habitats in the Yarbrough and Hensley (1980) study and the present study, respectively.

Colbert et al. (1974) found that river borders and dike fields together made up 57 percent of their study area, and Yarbrough and Hensley (1980) found that main channel borders comprised 53 percent of the pooled river. The present study limited main channel borders to the edge of

the wing dams, and that limitation probably accounted for the comparatively low percentage (38 percent) of area defined as main channel border.

Both Colbert et al. (1974) and Yarbrough and Hensley (1980) found that less than 10 percent of the study area consisted of main channel habitat. The present study identified 18 percent of the area as main channel. Again, this probably reflects the difference in the definition of main channel and main channel border between the studies.

The total aquatic habitat acreages measured by Yarbrough and Hensley (1980) and the present study (Table 5.1-2) differed by 2.1 percent. Hagen et al. (1977) also measured aquatic habitats in Pools 24, 25, and 26 and the total acreages measured differed from those in the present study by 4.6 percent.

BENTHIC INVERTEBRATES

Several investigators have collected benthic invertebrates in the upper Mississippi River, including some collection sites investigated in the present study. All of the benthic studies reviewed emphasize the dominance of oligochaetes in nearly all habitats and seasons (Hall, 1980; Emge et al., 1974; Sparks et al., 1979; Colbert et al., 1975; Union Electric, 1972). The only exception found occurred in the main channel habitat, which was not sampled for benthos in the present study. Emge et al. (1975) found that various Insecta taxa were numerically dominant in the main channel, with Oligochaeta being second in abundance. However, oligochaetes dominated the benthic biomass in the main channel.

Besides Oligochaeta, other abundant and well-distributed taxa include Diptera, Trichoptera, and Ephemeroptera, with Chironomus and Hexagenia being two of the most abundant genera (Hall, 1980; Emge et al., 1975).

Grace and Weithman (1982), in sampling stone dikes in the vicinity of the Ste. Genevieve site with dredges and artificial substrates, found that Oligochaeta, Ephemeroptera, and Diptera taxa comprised 85 percent of the benthos collected.

Backwater and quiet water habitats provide some of the most productive habitats for benthic invertebrates (Schramm and Lewis, 1978; Neuswanger, 1980; Colbert et al., 1975; Sparks et al., 1979). Side channels and main channel border habitats have been identified as key benthic invertebrate habitats by several investigators (Colbert et al., 1975; Sparks et al., 1979; Neuswanger, 1980), in terms of both benthic diversity and density. Dike fields have been identified as key benthic habitats in the upper river, serving as concentration zones for benthos, especially in areas where little other suitable habitat is present (Hall, 1980). Ragland (1974) found side channels in the open river to be dominated by Oligochaeta, Ephemeroptera, and Diptera, with main channel borders more abundant in Trichoptera and Ephemeroptera. Emge et al. (1974) found most side channels and main channel borders dominated by Oligochaeta and Diptera in the open river. Ragland (1974) utilized artificial substrates and dredge samplers. Emge et al. utilized only dredge samplers.

Several factors have been identified as key influences upon benthic populations and composition. These factors include substrate characteristics, current velocity, water level, discharge, and season (Hall, 1980). These are consistent with influencing factors discussed earlier in this study. Silt-clay substrates have been found to be the most suitable for benthic development, whereas substrates high in sand-gravel are least suitable for benthic colonization (Hall, 1980).

In terms of seasonal changes in benthic communities, several investigations in or near the study area have found that benthic diversity, biomass, and density reach a maximum in the late summer or fall (Union Electric, 1972; Sparks et al., 1979; Colbert et al., 1975;

Emge et al., 1975). This increase may be due to several factors, including increasing primary productivity, reduced discharge and current velocity, and natural life cycle features.

The ecological requirements and pollution tolerance data for important benthic organisms are summarized in Tables 6.4-1 and 6.4-2.

FISHERIES

Relative to the available data base on benthic invertebrates in the Upper Mississippi River, the existing fishery data base is more extensive and more site-specific to the present study. A number of fisheries investigations have been conducted in the various habitats of the GREAT III reach. In the following sections, data and conclusions from the present study will be compared to those from previous investigations

Species Composition/Relative Abundance

During the present study, fish sampling efforts yielded the majority of the species known to currently occur in the Upper Mississippi River. Table 6.5-1 lists those fish species recently recorded for the study area but not collected in the present study. The consistently dominant species are gizzard shad, carp, freshwater drum, and channel catfish. Other common fish include bluegill, shortnose gar, river carpsucker, and crappie (Sparks et al., 1979; Union Electric, 1972; Ragland, 1974; Dunham, 1971; Bertrand and Lockart, 1973; Bertrand and Dunn, 1973; Bertrand and Allen, 1973; Bertrand and Garver, 1973).

Relative abundance and dominant species depend in part upon the specific habitat being considered. The species listed above are common or abundant in many habitats. Shad and carp are the dominant species in nearly every habitat sampled.

The most important commercial fish species in the study area, as indicated by commercial fisheries statistics, are carp, buffalo,

Table 6.5-1. Fish Species Not Collected in the Present Study But Known to Occur in the GREAT III Study Area.

Common Name	Scientific Name
Silver lamprey	*Ichthyomyzon unicuspis*
Lake sturgeon	*Acipenser fulvescens*
Pallid sturgeon	*Scaphirhynchus albus*
Alligator gar	*Lepisosteus spatula*
Alabama shad	*Alosa alabamae*
Central mudminnow	*Umbra limi*
Grass pickerel	*Esox americanus*
Sturgeon chub	*Hybopsis gelida*
Sicklefin chub	*H. meeki*
Gravel chub	*H. x-punctata*
Bigeye shiner	*Notropis boops*
Ghost shiner	*N. buchanani*
Striped shiner	*N. chrysocephalus*
Bigmouth shiner	*N. dorsalis*
Pugnose minnow	*N. emiliae*
Spottail shiner	*N. hudsonius*
Silverband shiner	*N. shumardi*
Blacktail shiner	*N. venustus*
Silverjaw minnow	*Ericymba buccata*
Suckermouth minnow	*Phenacobius mirabilis*
Ozark minnow	*Dionda nubila*
Western silvery minnow	*Hybognathus argyritis*
Mississippi silvery minnow	*H. nuchalis*
Plains minnow	*H. placitus*
Largescale stoneroller	*Campostoma oligolepis*
Blue sucker	*Cycleptus elongatus*
White sucker	*Catostomus commersoni*
Silver redhorse	*Moxostoma anisurum*
Northern hog sucker	*Hypentelium nigricans*
Tadpole madtom	*Noturus gyrinus*
Stonecat	*N. flavus*
Pirate perch	*Aphredoderus sayanus*
Starhead topminnow	*Fundulus dispar*
Blackstripe topminnow	*F. notatus*
Blackspotted topminnow	*F. olivaceous*
Brook silversides	*Labidesthes sicculus*
Burbot	*Lota lota*
Spotted bass	*Micropterus punctulatus*

Table 6.5-1. Fish Species Not Collected in the Present Study But Known to Occur in the GREAT III Study Area. (Continued, Page 2 of 2)

Common Name	Scientific Name
Rock bass	*Ambloplites rupestris*
Flier	*Centrarchus macropterus*
Longear sunfish	*Lepomis megalotis*
Logperch	*Percina caprodes*
Slenderhead darter	*P. phoxocephala*
River darter	*P. shumardi*
Johnny darter	*Etheostoma nigrum*
Bluntnose darter	*E. chlorosomum*
Mud darter	*E. asprigene*
Orangethroat darter	*E. spectabile*

Sources: ESE, 1982.; Pflieger, 1975; Smith, 1979; Sparks et al., 1979; Emge et al., 1974; Schramm and Lewis, 1974; Ragland, 1974; Grace and Weithman, 1982; UMRCC, 1982.

freshwater drum, and channel catfish (Sparks et al., 1979). Sparks et al. (1979) list the following species as most commonly caught by sport fishermen (in approximate order of decreasing catch): freshwater drum, channel catfish, carp, crappie, green sunfish, white bass, bluegill, flathead catfish, blue catfish, and largemouth bass.

Seasonal Changes and Trends

The taxonomic composition and relative abundance of the fish populations have been found to be generally consistent from season to season. For the most part, there are no significant migratory or seasonal fishes (species which are anadromous or exhibit significant seasonal differences in habitat associations) found in the study area. A majority of the species found will move into shallow waters, tributaries, and quieter backwaters for spawning purposes and as refuges during high water periods. Thus, concentrations of fish in the spring and early summer often occur in these habitats.

Late summer and early fall are often periods of greater absolute and relative abundance for a number of the more common fishes, notably the shad, carp, and drum. This increased abundance is primarily due to the high reproductive potential of these species and the abundance of young-of-the-year individuals following the spawning periods in spring and early summer.

A number of investigators indicate that maximum density and diversity in the fishery, as expressed by maximum catches-per-unit effort, generally occur in mid to late summer, whereas minimum harvests and diversity are attained in the late fall (Dunham, 1971; Bertrand and Lockart, 1973; Bertrand and Dunn, 1973; Bertrand and Garver, 1973; Bertrand and Allen, 1973). A number of factors may be involved in this trend. Collection methods may be more effective during summer (typically low flow) river conditions. Fish metabolic activity may be at its highest level, thereby increasing the distribution and movement of fish and [illegible]

in greater catch-per-effort. Summer water and river conditions may enhance fish movement into, and habitation of, backwater and quiet water habitats, whereas fish may move into deeper waters and main river habitats in colder seasons. However, extreme low water levels may cause concentrations of fish in main river habitats during late summer or fall.

<u>Habitat Associations</u>

A number of investigations involved sampling and comparisons of the fish communities of different habitats in the GREAT III study area. A majority of these investigations used a habitat classification system similar to that of the present study and focused on sampling of side channels, sloughs, river lakes, and main channel border habitats.

Fisheries data resulting from these investigations consistently indicate the importance of side channels and river lakes as key fishery habitats, in terms of both diversity and productivity. Main-channel border and main channel habitats have been found to be far less productive and to support a much less diverse fishery (Dunham, 1971; Bertrand and Lockart, 1973; Bertrand and Dunn, 1973; Bertrand and Garver, 1973; Bertrand and Allen, 1973).

Fisheries biologists with the Illinois Department of Conservation (IDOC) have sampled in the Clarksville, Ste. Genevieve, and Cape Girardeau sampling areas as well as near the Winfield sampling area. In some cases, their sampling locations were close to those used in the present study, including the Kaskaskia and Picayune side channels, the Batchtown Wildlife Refuge, and tailwaters of Pools 24 and 25. Grace and Weithman (1982) investigated fish communities of stone dikes in a reach near the Ste. Genevieve sampling site during 1981.

These data indicated that side channels and river lakes are generally the most productive habitats (numbers per unit effort). Although

diversity values were not calculated, these same habitats generally supported the greater diversity of fish species.

The following habitat associations of abundant fish species have been determined from the available data (Dunham, 1971; Bertrand and Lockart, 1973; Bertrand and Dunn, 1973; Bertrand and Garver, 1973; Bertrand and Allen, 1973; Ragland, 1974; Grace and Weithman, 1982):

<u>Main Channel Border</u>
- Gizzard shad
- Carp
- Freshwater drum
- River Carpsucker
- Channel catfish

<u>Side Channel</u>
- Gizzard shad
- Shortnose gar
- Carp
- Buffalo
- River carpsucker
- Freshwater drum
- Bluegill

<u>Slough</u>
- Gizzard shad
- Carp
- Bluegill
- Freshwater drum

<u>River Lake</u>
- Bluegill
- Gizzard shad
- Carp
- Largemouth bass

<u>Tailwater</u>
- Gizzard shad
- Carp
- Freshwater drum
- White bass
- Sauger

<u>Stone Dike</u>
- Gizzard shad
- Carp
- River carpsucker
- Freshwater drum
- Shortnose gar
- Emerald shiner
- Flathead catfish

Bertrand and Garver (1973) compared fisheries of pile and stone dikes in the Chester-Ste. Genevieve vicinity. They found that pile dikes yielded significantly fewer fish per unit effort than the stone dikes. Gizzard shad and freshwater drum were the most common associates of the stone dikes. Carp, shortnose gar, and blue catfish were associated with the pile dikes. The pile dike was notable for its blue catfish populations.

Grace and Weithman (1982) found the dominant fish species associated with stone dikes to be gizzard shad, carp, river carpsucker, freshwater drum, shortnose gar, emerald shiner, and flathead catfish.

LGL Associates (1981) investigated the fishery of the main channel habitat in the GREAT II river segment. Although 39 species were collected in the main channel, the productivity and diversity of the main channel fishery were significantly lower than those of other habitats sampled by other investigators. The most abundant species in the main channel were: channel catfish, silver chub, mooneye, shovelnose sturgeon, freshwater drum, flathead catfish, and river darter.

A number of other investigators have found extra-channel habitats such as sloughs and side channels to be the most productive fishery habitats (Schramm and Lewis, 1974; Ellis, 1978). The Great River Environmental Action Team (GREAT II, 1980) considered these extra-channel habitats to be key habitats for significant life history requirements (notably feeding, spawning, and nursery activities).

Various factors are considered important in influencing habitat associations of major fish species. These factors include: current, water depth, turbidity, water level fluctuations, substrate characteristics, and dissolved oxygen levels. Cover, in the form of vegetation and submerged structures, has been identified as an important factor for some species. Predator-prey relationships may also influence the distribution and habitat associations of certain fish, especially the carnivorous predators and the forage species (Gutreuter, 1980).

The habitat associations described above, based on literature data and conclusions, are generally similar to those described in the present study. Side channels, sloughs, river lakes, and navigation pools were consistently identified as the key habitats for a majority of species

found in the study area. The main river habitats supported a significantly lower number and diversity of fishes.

FISHERIES LIFE HISTORY INFORMATION

Descriptive information is presented below which emphasizes features relevant to habitat associations and life history utilization of habitats. Information in this section is taken from Pflieger (1975), Farabee (1979), and Smith (1979) and from data collected during the study.

The paddlefish (Polyodon spathula) is primarily an open or deepwater species generally found in deep pools and deep backwaters of major rivers. It feeds largely upon zooplankton and other invertebrates. Although little is known about spawning activity, it is believed to begin in April and has been generally observed to occur over gravel bottoms in sustained deep water.

The shovelnose sturgeon (Scaphirhynchus platorynchus) is one of the few species typically inhabiting main channel and tailwater habitats, areas of strong current. The sturgeon is a bottom dweller in open channels of large rivers and in the tailwaters of dams and reservoirs. It generally prefers areas with strong current and rock or gravel bottom. The sturgeon feeds primarily on benthic macroinvertebrates. Spawning takes place in the open water, often in tailwater habitat usually reaching a peak in May. Although the sturgeon has limited value as a sport fish, it is one of the most valuable commercial species in the Mississippi River, with demand far exceeding the catch.

The bowfin (Amia calva) is a common inhabitant of floodplain lakes, oxbows, and backwater areas of the Mississippi River system. It is especially common in heavily vegetated, warmer waters. The bowfin is tolerant of a variety of environmental and ecological conditions, but prefers sluggish waters of relatively low turbidity. Primary food [illegible]

of adult bowfin are crayfish and fish. The young feed on microcrustaceans and other small invertebrates. Spawning takes place from April through June, on clean rock or gravel substrates in zones of heavy vegetation. Bowfin are periodically caught by fishermen, but their sport and commercial value is limited.

The gar (Lepisosteus spp.) is a major predator in the aquatic systems of the Mississippi River. The shortnose (L. platostomus) and longnose gar (L. osseus) are the most common species in the study area. They inhabit most quiet-water habitats and are tolerant of ecological and environmental conditions. The gar is most common in littoral and side channel areas. It feeds primarily on other fish and some invertebrate prey. It spawns in shallow water habitats, especially those with aquatic macrophyte development. The gar has very little value as either a sport or commercial fish.

The gizzard shad (Dorosoma cepedianum) is probably the most abundant fish in the Mississippi River system as well as in most other midwestern aquatic habitats. It was the most abundant fish collected during field collection efforts. The gizzard shad is a pelagic spawner producing pelagic eggs and larvae. It is highly tolerant of environmental stress and is found in all habitat types. It is primarily planktivorous in feeding habits. The gizzard shad has limited value as a commercial or sport species, but it is important as a forage fish for predatory species.

The cyprinid family is a large and diverse group which has the greatest representation in most aquatic environments. The following cyprinids were collected during this study:

Grass carp	(Ctenopharyngodon idella)
Carp	(Cyprinus carpio)
Golden shiner	(Notemigonus crysoleucas)
Silver chub	(Hybopsis storeriana)

Speckled chub	(*H. aestivalis*)
Flathead chub	(*H. gracilis*)
Emerald shiner	(*Notropis atherinoides*)
Redfin shiner	(*N. umbratilis*)
River shiner	(*N. blennius*)
Steelcolor shiner	(*N. whipplei*)
Spotfin shiner	(*N. spilopterus*)
Red shiner	(*N. lutrensis*)
Sand shiner	(*N. stramineus*)
Mimic shiner	(*N. volucellus*)
Bullhead minnow	(*Pimephales vigilax*)
Bluntnose minnow	(*P. notatus*)
Fathead minnow	(*P. promelas*)
Central stoneroller	(*Campostoma anomalum*)

The above species are generally widely distributed, tolerant, and commonly associated with big river habitats. Cyprinids are more closely associated with flowing waters than with standing waters. General habitat associations of the cyprinids collected in this study are as follows:

	Large Rivers	
Small Streams	Main River	Backwaters/Pools
Hornyhead chub	Grass carp	Golden shiner
Redfin shiner	Speckled chub	Red shiner
Bigmouth shiner	Flathead chub	Sand shiner
Steelcolor shiner	Silver chub	Bullhead minnow
Spotfin shiner	Emerald shiner	Bluntnose minnow
Fathead minnow	River shiner	
Central stoneroller	Mimic shiner	

The majority of cyprinids feed on aquatic invertebrates, but some feed on attached algae and phytoplankton or combine these foods with their invertebrate diet. The carp is an omnivorous feeder, extracting plant and animal material from bottom sediments. The grass carp feeds primarily on aquatic ma hytes.

Spawning periods for cyprinids are relatively lengthy, extending from spring through a majority of the summer, peaking in May and June. Spawning occurs in a variety of habitats.

Carp (Cyprinus carpio) is one of the most abundant and widespread fish of the Mississippi River. It is found in nearly all habitats with few restrictions on seasonal or spatial distribution. Highly tolerant of ecological or environmental stresses, the carp is a significant commercial species as well as a major sport species for some fishermen. Carp are associated with nearly any substrate, cover or current type. It is a bottom feeder with a diet of detritus and benthic invertebrates. The carp is basically a random spawner, depositing eggs on a variety of substrates but preferring submerged vegetation.

The carpsuckers (Carpiodes spp.) and buffalo (Ictiobus spp.) are common representatives of the sucker family (Catostomidae) in the Mississippi River. Both genera are widely distributed in a variety of habitats but are usually associated with soft substrates from which they feed upon benthic invertebrates and organic detritus. Both buffalo and carpsuckers are associated with quiet slackwater or backwater habitats but generally prefer areas of slight to moderate current for spawning purposes.

Of the quillback (Carpiodes cyprinus), river carpsucker (C. carpio), and highfin carpsucker (C. velifer), the river carpsucker is the most abundant and widely distributed in the Mississippi River. The highfin carpsucker is primarily associated with clean-water, hard-substrate habitats. All three species prefer quiet-water habitats except for spawning purposes, at which time they move into gravel-rock riffles. Spawning generally occurs in spring and early summer.

The bigmouth (Ictiobus cyprinellus) and smallmouth buffalo (I. bubalus) are generally similar in habitat preference for deep quiet pools. Spawning occurs in late spring and summer in quiet backwater habitats, especially where mudflats and vegetation occur.

Three redhorse species were collected during the study, the shorthead redhorse (Moxostoma macrolepidotum), the river redhorse (M. carinatum) and the golden redhorse (M. erythrurum). The redhorse species are similar in their habitat requirements and life history features. They prefer the open water areas of larger rivers, inhabiting rocky or gravelly bottoms in zones of strong current. Principle food items are aquatic invertebrates and, in the case of the river redhorse, molluscs.

The channel catfish (Ictalurus punctatus) is one of the major sport and commercial fishes of the Mississippi River. It is an abundant and widely distributed species, found in virtually all habitats. It is most abundant in moderately deep littoral areas with an abundance of snags, tree roots and undercut banks. The channel catfish feeds in shallow waters, extracting benthic macroinvertebrates and plant materials from the soft sediments, or picking organisms from rocks and other solid substrates. Spawning usually occurs from late May through July. Eggs are deposited in natural cavities among logs or snags or in undercut banks, usually in quiet, secluded waters. The channel catfish is a highly tolerant and adaptable species and is perhaps the prize sport and commercial fish in this reach of the Mississippi River.

The flathead catfish (Pylodictus olivaris) is similar to the channel catfish in terms of ecological requirements and preferences. It is, however, less abundant and less widely distributed. The flathead prefers moderately deep and quiet waters with abundant cover in the form of snags, tree roots, or bank cavities. Flatheads feed primarily on invertebrates, fish, and crayfish. Spawning takes place in late June and July. Eggs are deposited in natural cavities among logs and roots, or in bank cavities. Like the channel catfish, the flathead is a widely sought sport and commercial species in the Mississippi River.

The most common ictalurid collected during the study was the black bullhead (Ictalurus melas). Although the channel catfish is more widely distributed in a variety of habitats, the black bullhead is generally

the more abundant where it occurs. The preferred habitats of the black bullhead are quiet backwaters and pools with soft bottoms and high turbidity. The bullhead feeds primarily upon aquatic insects and small crustaceans gleaned from bottom substrates. Black bullheads generally spawn in May or June. Eggs are deposited on soft bottoms, usually under submerged logs or similar structures affording cover. The black bullhead is a popular sport fish but has limited value as a commercial species.

Both the yellow bullhead (Ictalurus natalis) and brown bullhead (I. nebulosus) were collected during the study, but as would be expected, few individuals were collected. Both species prefer quiet, clearer waters with dense growths of aquatic vegetation. They are primarily bottom feeders with a diet comprised of insects and crustaceans. Spawning characteristics are similar to those of the black bullhead.

White bass (Morone chrysops) and yellow bass (Morone mississippiensis) were collected during the study. White bass was the more common, but both species are common in the pool, littoral, and backwater habitats and frequently concentrate in tailwater habitats in early spring. They feed on aquatic invertebrates during early life, turning to a predominantly fish diet as adults.

Both the white and yellow bass move into tributary streams for spawning, which generally occurs in March and May. The white bass tends to spawn in open waters over rocky or gravel bottoms. The yellow bass tends to spawn in shallower waters, again over gravel bottoms.

Several taxa of Centrarchidae (bass, sunfishes, crappie) are common in the Mississippi River system. This family is a significant component of the fishery for sport purposes and because they provide a forage base for the larger predatory fish. Centrarchids are more commonly found in lotic water habitats, especially those having protective cover and

spawning habitat in the form of aquatic macrophytes. In the Mississippi river system, centrarchids are generally most abundant in sloughs, side channels, and floodplain lakes. Littoral zones and the margins of the navigation pools also support sizeable centrarchid populations.

The centrarchids are predominantly carnivorous. Younger individuals feed on planktonic and benthic invertebrates. Older (larger) individuals feed on macroinvertebrates and fishes. Larger bass (Micropterus spp.), when present in a habitat, are generally the top predator. Centrarchids associate with vegetated zones for spawning purposes. Specific spawning activities are variable among taxa; usually occurring on or in beds of aquatic macrophytes or on shallow-water substrates protected by aquatic macrophytes and similar cover.

The largemouth bass (Micropterus salmoides) is common in flowing and standing waters and quiet backwaters. It is one of the more actively sought sport fish. The largemouth bass inhabits deeper water habitats and slackwater or backwater zones. Spawning occurs in spring to early summer. Prime spawning areas are rock or gravel bottoms in relatively clear water, near vegetation or similar cover.

The smallmouth bass (Micropterus dolomieui) replaces the largemouth bass in smaller clear streams, and is less tolerant of turbidity and siltation. In the Mississippi River, the largemouth bass is more common and widely distributed than the smallmouth bass. The smallmouth is most common in zones of dense cover and in rock-gravel shoals or riffles and along wing dams and revetments. Spawning occurs in shallow waters near cover and on firm bottoms. The peak spawning period is from April through June.

Bluegill (Lepomis macrochirus) is one of the most abundant and widely distributed sunfishes in the Mississippi River system. Although it reaches its peak abundance in ponds and smaller lakes, it is a common inhabitant of backwater areas, impoundments and floodplain lakes in and

along major river systems. Bluegill move into shallow waters for feeding and spawning activities. They generally construct a spawning nest in shallow water with gravel bottom. The spawning period extends from May through August with a spawning peak in June.

The green sunfish (Lepomis cyanellus) is another common sunfish of the Mississippi River system, and is probably one of the most widely distributed fish of those collected. It has been collected in virtually every aquatic habitat. The green sunfish is tolerant of a wide range of environmental and ecological conditions and has few habitat restrictions.

Spawning, however, usually occurs in gravelly or rocky shallow waters with little or no current. The spawning period occurs May through August, with a peak in June.

The white crappie (Pomoxis annularis) and black crappie (P. nigromaculatus), although frequently collected in the Mississippi River system, are not as widely distributed or ecologically tolerant as the bluegill and green sunfish. The crappies are generally associated with shallow or backwater areas providing some cover, as well as with floodplain lakes. Principal food items include microcrustaceans, insects, and fish. Spawning occurs from April through June and takes place in shallow protected waters with silt-free substrates.

Sauger (Stizostedion canadense) primarily inhabits side channels and tributary mouths providing abundant cover. They feed largely on aquatic invertebrates and, as adults, upon fish. Spawning begins in April and occurs over rocky shoals exposed to good flow. Sauger are often found in abundance in tailwater and main channel habitats, notably during spring and probably in association with spawning activities.

The freshwater drum (Aplodinotus grunniens) is essentially a species of large rivers and reservoirs. In the Mississippi, it is widely

distributed and abundant, especially in deeper waters having some current. The drum is a bottom-dweller and feeds primarily on bottom invertebrates. It is a pelagic or open-water spawner, ejecting eggs and sperm in the open water. Spawning primarily occurs in April and May. The drum is a major commercial species and is frequently caught by sport fisherman.

7.0 RESULTS AND DISCUSSION FOR OTHER BIOLOGICAL COMMUNITIES

7.1 MUSSELS

Mussel sampling was conducted by dragging a 10-foot crowfoot brail for two 10-minute tows at each designated habitat type. Nine species of mussels were collected using this method. Two species of mussels were collected incidentally in nets or on a grapple hook.

Previous data indicate that 28 species have been collected within the GREAT III reach (Kindschi, ed., 1980). Twenty of the 28 species have been collected between Alton and the mouth of the Ohio, and 21 of the 28 species have been collected in Pools 24, 25, and 26.

No large mussel beds were located during the sampling effort; however sampling was somewhat limited by the designated habitats and by the effort extended. Lubinski, et al. (1981) provides statistical correlations indicating that low numbers of mussel species per pool were associated with high levels of recent dredging. Other conditions may influence this association, but because this exists, there is a potential cause-effect relationship. Although the data collected by ESE are inconclusive, some inferences can be made regarding dredging activities and mussel populations.

MUSSELS COLLECTED/RELATIVE ABUNDANCE

Thirty-one mussels representing 11 species were collected during the sampling effort (Table 7.1-1).

The most frequently collected species were 7 *Amblema plicata* (three-ridge) and 7 *Quadrula quadrula* (maple leaf). Four *Obovaria olivaria* (hickory nut) were collected.

ASSOCIATION OF MUSSELS

Sampling Areas

Of the 31 specimens collected, 30 (96.8 percent) were collected within the Clarksville and Winfield pools. Seventy-four percent (23) of the specimens were collected at the Winfield sampling site (Pool 25) and 22.6 percent (7) were collected at the Clarksville site (Pool 24). Four species, Amblema plicata, Quadrula quadrula, Obovaria olivaria, and Truncilla donaciformes were represented in Clarksville, while nine species, Amblema plicata, Fusconia flava, Megalonaias gigantea, Quadrula nodulata, Quadrula quadrula, Lampsilis anodontoides, Leptodea fragilis, Obovaria olivaria, and Obliquaria reflexa were represented in the samples taken at the Winfield pool. One mussel, Truncilla spp., was collected at the Ste. Genevieve site, while none were collected at the Cape Girardeau site.

Habitat Types

At least one mussel was captured in each habitat type sampled. However, the majority (54.8 percent) were captured in the dike field habitat. The outside bend-channel border habitat yielded 16.1 percent of the total catch, the straight stretch-channel border yielded 6.5 percent of the catch, while the other habitats sampled yielded only 3.2 percent of the catch each (Table 7.1-2).

Three mussels were captured in the navigation pool and one mussel was captured in the tailwaters; however, these mussels were captured incidentally in frame nets or gill nets. Further sampling in these areas would be necessary to determine mussel concentrations.

The catch-per-effort was highest in the Winfield dike field habitat. Catch-per-effort at the remaining habitats sampled was low, less than one mussel per 10-minute tow.

The data indicate that the concentration of mussels at any of the habitats is low. [illegible] the GREAT III reach might reveal population within this stretch of the Mississippi River.

Table 7.1-3 lists mussel species considered threatened, endangered, or rare in Illinois and Missouri and potentially occurring in the GREAT III reach. <u>Obovaria olivaria</u> and <u>Quadrula nodulata</u> were collected and are considered state endangered, but are locally common in portions of the GREAT III reach (Nordstorm <u>et al</u>, 1977; Buchanan, A., personal communication, 1982).

Table [illegible]. Species of [illegible]

Species	Clarksville #	Clarksville %	Winfield #	Winfield %	Mo. Crossing #	Mo. Crossing %	Cape Girardeau #	Cape Girardeau %	Total #	Total %
Threeridge *Amblema plicata*	1	14.3	6	26.1	0		0		[illegible]	[illegible]
Pigtoe *Fusconaia flava*	0		2	8.7	0		0		[illegible]	[illegible]
Washboard *Megalonaias gigantea*	0		2	8.7	0		0		[illegible]	[illegible]
Warty-back *Quadrula nodulata*	0		2	8.7	0		0		2	6.5
Maple leaf *Quadrula quadrula*	3	42.9	4	17.4	0		0		7	22.6
Yellow sandshell *Lampsilis anodontoides*	0		1*	4.3	0		0		1	3.2
Fragile papershell *Leptodea fragilis*	0		2	8.7	0		0		2	6.5
Hickory nut *Obovaria olivaria*	2	28.6	2	8.7	0		0		4	12.9
Truncilla spp.	0		0		1	100.0	0		1	3.2
Fawn's foot *Truncilla donaciformis*	1	14.3	0		0		0		1	[illegible]
Three-horned warty back *Obliquaria reflexa*	0		2	8.7	0		0		[illegible]	[illegible]
TOTAL	7		23		1		[illegible]		[illegible]	

Source: [illegible], 1982.

Table 7.1-2. Mussels Collected by Habitat at each Sampling Area on the Mississippi River, GREAT III Reach

Habitat	Clarksville #	Clarksville C/E	Winfield #	Winfield C/E	Ste. Genevieve #	Ste. Genevieve C/E	Cape Girardeau #	Cape Girardeau C/E	Total #	Total %
Dike field	1	0.125	16*	1.875	0	0	0	0	17	54.8
Main channel	1	0.125	0	0	0	0	0	0	1	3.2
Inside bend	0	0	1	0.125	0	0	0	0	1	3.2
Outside bend	2	0.25	2	0.25	1	0.125	0	0	5	16.1
Straight reach	0	0	2	0.25	0	0	0	0	2	6.5
Side channel	0	0	1	0.125	0	0	0	0	1	3.2
Navigation pool*	2		1		0		0		3	9.7
Tailwaters*	1		0		0		0		1	3.2
TOTAL	7		23		1		0		31	

*Collected incidentally in nets or on grapple hook.

Source: ESE, 1982.

Table 7.1-3. Threatened, Endangered, and Rare Mussel Species Potentially Occurring in the GREAT III Reach

Species	Status	
	State*	Federal
Arcidens Confragosus	Endangered	None
Fusconaia ebena	Endangered	None
Lampsilis higginsi	Endangered	Endangered
Obovaria olivaria	Endangered	None
Proptera (Potamilus) capax	Endangered	Endangered
Quadrula nodulata	Endangered	None
Anodonta grandis corpulenta	Rare	None
Cumberlandia mondonta	Rare	None
Plethobasis cooperianus†	--	Endangered
Lampsilis orbiculata†	--	Endangered
Pleurobema plenum†	--	Endangered
Epioblasma torulosa torulosa†	--	Endangered

* State of Missouri only, the State of Illinois recognizes the Federally listed species only.
† Primarily Wabash River and Ohio River species. They have limited potential of occurring in the lower reaches of the GREAT III study area.

Sources: U.S. Fish and Wildlife Service, 1980.
Nordstrom et al., 1977
Illinois Natural Land Institute, 1981.
Buchanan; personal communication, 1982.

7.2 FINGERNAIL CLAMS

Data were collected on the presence and density of fingernail clams (Sphaeriidae) in the pooled portion of the river in late March and early April 1982. Four locations were selected based upon fall and winter 1981/82 aerial surveys of diving duck concentrations, as well as the historic location of migrating diving duck concentrations on the Mississippi River in the GREAT III study reach (Illinois Natural History Survey).

Selected study areas were: Transect A--downstream of Piasa Island (Pool 26), Transect B--Eagles Nest Island Area (Pool 26), Transect C--Winfield Navigation Pool (Pool 25), and Transect D--Clarksville Navigation Pool (Pool 24) (Figures 7.2-1, 7.2-2, and 7.2-3).

Fingernail Clam Distribution and Density

Sphaerids were present at all of the collection sites. Sphaerids were widely distributed at Transects C and D where fingernail clams were present in the collections at all sampling stations. Collections at Transect A resulted in sphaerids being present at 4 of the 6 stations, while at Transect B, sphaerids were collected at only 2 stations (Tables 7.2-1, 7.2-2, 7.2-3, and 7.2-4).

Highest sphaerid densities were collected at Transect A (Piasa Island) 28.7-315.8/m^2 and Transect C (Winfield Navigation Pool) 28.7-358.8/m^2. Intermediate densities were collected at Transect D (Clarksville Navigation Pool) 28.7-114.8/m^2.

Throughout the four sampling transects, the dominant sphaerid in the collections was Sphaerium spp. The genera Musculium and Pisidium were less common in the collections.

One factor possibly influencing the densities of fingernail clams present during sampling would be the recent predation (feeding) by diving ducks earlier in the spring. A second factor could be the generally low reproductive activity occurring in winter and early spring.

<u>Fingernail Clam Associations</u>

Fingernail clams were present at all four sampling transects. These sampling areas are known to be frequented by diving ducks during seasonal migrations.

The bottom substrates at which sphaerids were most abundant in the collections were soft substrates, typically composed of silt and fine sand. Coarse substrates (pebbles, coarse sand) were not common in the study area, but generally supported low sphaer..d densities. Gale (1973), however, indicated that substrate selection did not appear to influence the distribution of <u>Sphaerium striatinum</u>.

Water depths of 2 to 10 feet (0.6-3.3 meters) were sampled during the study. Sphaerids were present at all depths; however, the highest densities were present at depths of 3 to 5 feet (1-1.7 meters). Current velocity, approximately 2-4 fps, temperature, dissolved oxygen, pH and ammonia levels, although variable between transects, do not appear to have influenced sphaerid distribution.

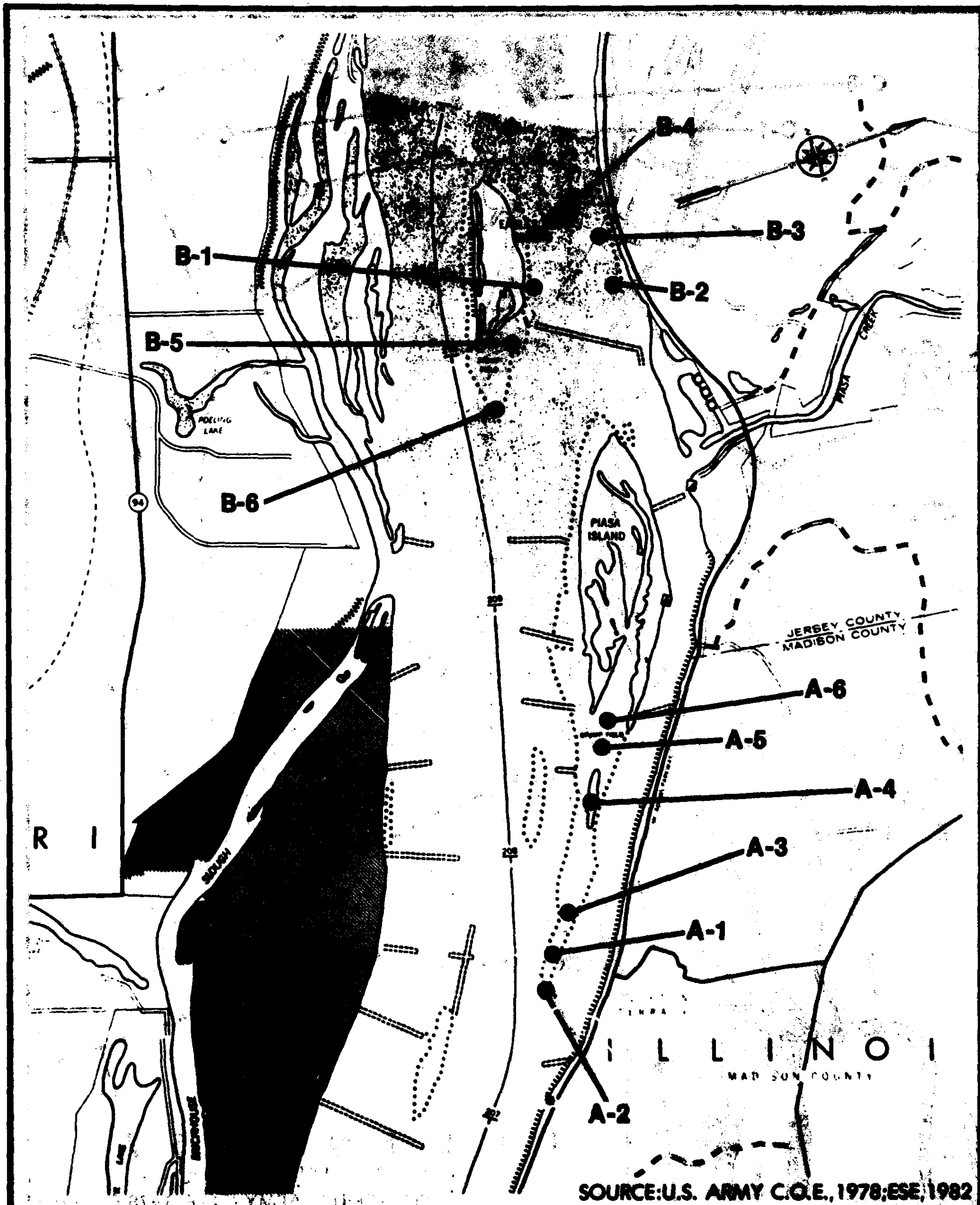
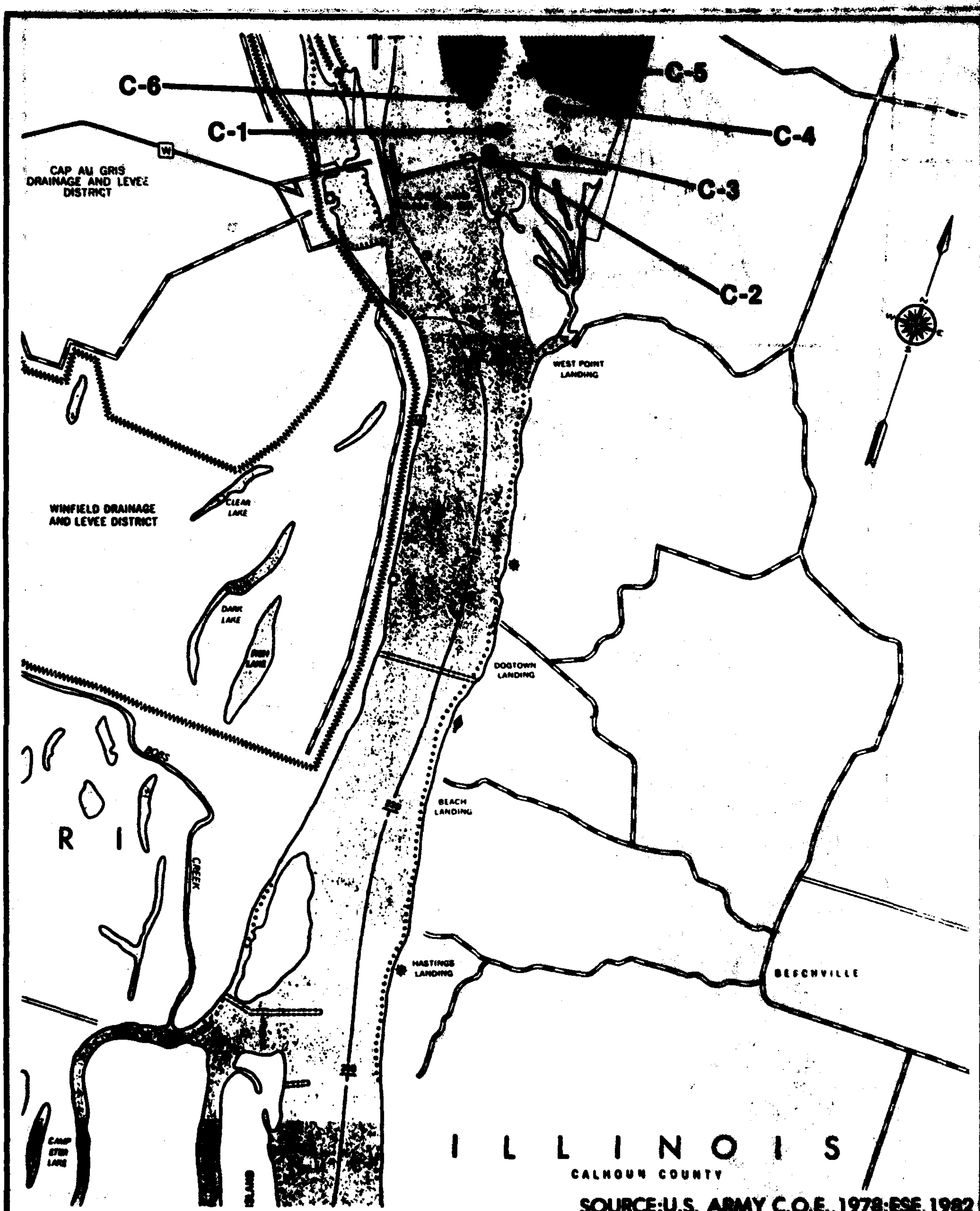


Figure 7.2-1
FINGERNAIL CLAM SAMPLING SITES-TRANSECTS
A AND B
ALTON POOL (26)
MISSISSIPPI RIVER MILES 206.6 TO 211.5

GREAT III ECOLOGICAL CHARACTERIZATION
St. Louis District Army Corps of Engineers



SOURCE:U.S. ARMY C.O.E. 1978;ESE 1982

Figure 7.2-2
FINGERNAIL CLAM SAMPLING SITES-TRANSECT C
WINFIELD POOL (25)
MISSISSIPPI RIVER MILES 237.5 TO 242

GREAT III ECOLOGICAL CHARACTERIZATION

St. Louis District Army Corps of Engineers

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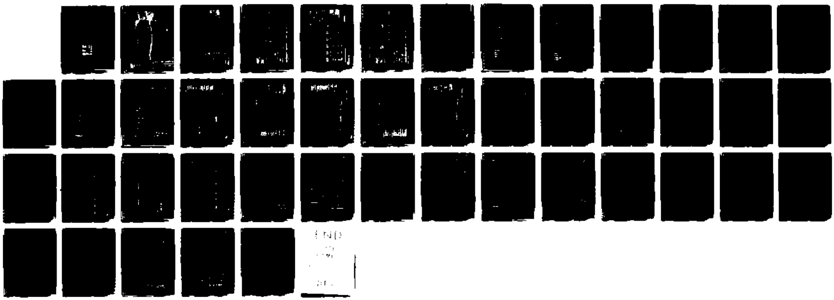
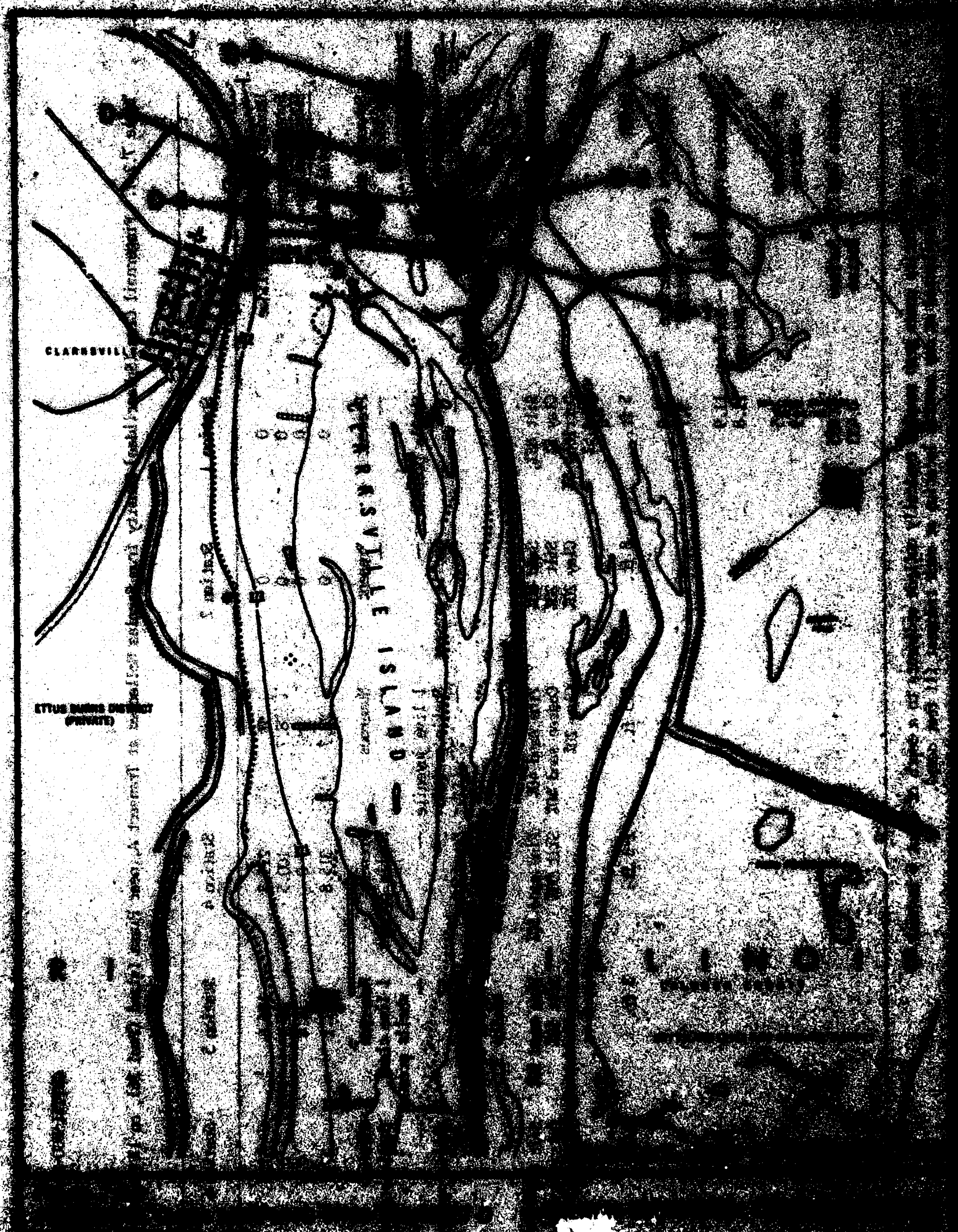
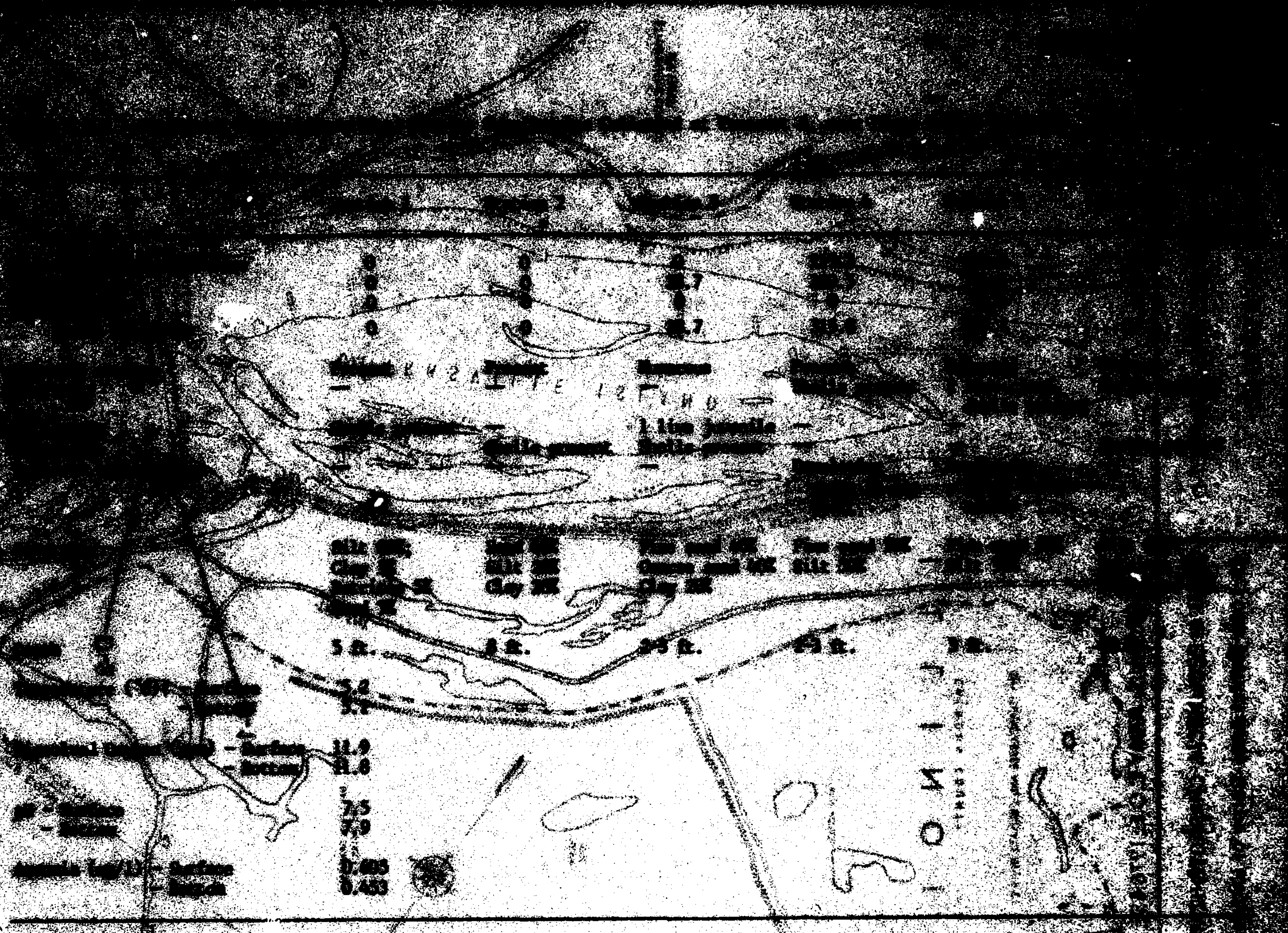



CLARKSVILLE



[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Silt [illegible] / Clay [illegible] / [illegible]	[illegible] / Silt [illegible] / Clay [illegible]	Fine sand [illegible] / [illegible] sand [illegible] / Clay [illegible]	Fine sand [illegible] / Silt [illegible]	[illegible]
Depth	5 ft.	8 ft.	2-5 ft.	4-5 ft.	3 ft.
[illegible] (°C) – Surface	5.4				
– Bottom	5.4				
[illegible] – Surface	11.9				
– Bottom	11.8				
pH – Surface	7.5				
– Bottom	7.9				
[illegible] (mg/l) – Surface	0.405				
– Bottom	0.453				

* [illegible] grab samplers typically collect sediments to a depth of about 4 inches).
† [illegible] collected at one central location at each transect (11 feet deep).

[illegible]

Table 7.2-4. Fingernail Clam (Sphaeriidae) Density from Samples Collected at Transect D, in the Clarksville Navigation Pool (Pool 24), on 18 March 1982

	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Unidentifiable sphaeriids	57.4	114.8	0	32.3	28.7	28.7
[illegible] spp.	28.7	0	14.4	0	0	0
[illegible] spp.	0	0	0	14.4	0	0
Total Sphaeriids	86.1	114.8	14.4	57.4	28.7	28.7
Sphaeriid shells	Numerous	Present	Present	Present	—	Numerous
Corbicula	Shells present	—	—	—	—	—
Pelecypoda	1 *Quadrula quadrula*	—	—	1 *Obliquaria reflexa*	—	—
Gastropoda	—	—	—	—	—	—
Sphaeriid reproduction	—	Developing young in one adult	—	Developing young in three adults	—	—
Substrate	Silt 90% Clay 10%	Silt 80% Clay 20%	Silt 50% Fine sand 50%	Silt 80% Clay 10% Fine sand 10%	Silt 90% Clay 10%	Silt 80% Clay 10% Fine sand 10%
Depth	4 ft.	3 ft.	8 ft.	6 ft.	2 ft.	3 ft.
Temperature (°C) - Surface	3.9					
- Bottom	3.9					
Dissolved Oxygen (ppm) - Surface	11.8					
- Bottom	11.6					
pH - Surface	7.1					
- Bottom	7.4					
[illegible] - Surface	1.31					
- Bottom	1.21					

[illegible] typically collect sediments to a depth of about 4 inches).
[illegible] location at each transect (11 feet deep).

[illegible]

7.3 NON-AQUATIC BIOTA

[illegible] Mammals [illegible] in the Pennsylvania [illegible] III Reach
(Continued, Page 2 of 4)

Species	Pooled Section	Open Section	Observed by [illegible]
Marsupialia Didelphidae			
Opossum			
Didelphis virginiana	X	X	C
Insectivora Soricidae			
Southeastern Shrew			
Sorex longirostris		X	
Short-tailed Shrew			
Blarina brevicauda	X	X	
Least Shrew			
Cryptotis parva	X	X	
Talpidae			
Eastern mole			
Scalopus aquaticus	X		
Chiroptera Vespertilionidae			
Little brown bat			
Myotis lucifugus	X		
Southeastern Myotis			
Myotis austroriparius			
Gray bat			
Myotis grisescens	X		
Keen's bat			
Myotis keenii	X	X	
Indiana bat			
Myotis sodalis	X		
Silver-haired bat			
Lasionycteris noctivagans	X	X	
E. Pipistrelle			
Pipistrellus subflavus	X		
Big-brown bat			
Eptesicus fuscus	X	X	
Red bat			
Lasiurus borealis	X		
Hoary bat			
Lasiurus cinereus			
Evening bat			
Nycticeius humeralis			

[illegible]

[illegible]

(Continued, Page [illegible])

Species		
Lagomorpha Leporidae		
E. Cottontail		X
Sylvilagus floridanus		
Swamp rabbit		
Sylvilagus aquaticus		
	X	
Rodentia Sciuridae		
E. Chipmunk		X
Tamias striatus		
Woodchuck	X	X
Marmota monax		
Thirteen-lined ground squirrel		
Spermophilus tridecemlineatus		
Franklin's ground squirrel		
Spermophilus franklinii		
Grey squirrel		
Sciurus carolinensis		
Fox squirrel		
Sciurus niger		
S. Flying squirrel		
Glaucomys volans		X
Geomyidae	X	X
Plain's Pocket Gopher		
Geomys bursarius		X
Castoridae	X	X
Beaver		
Castor canadensis		X
Cricetidae	X	X
[illegible]		
[illegible]		X
[illegible]		
[illegible]		
[illegible]		
[illegible]		
[illegible]		
[illegible]		
[illegible]		
[illegible]		

[illegible]

[illegible]

(Continued, [illegible])

Species		Wooded Section	Open Section	Observed*
E. Woodrat				
Neotoma floridana	X			
Meadow vole				
Microtus pennsylvanicus		X		
Prarie vole				
Microtus ochrogaster		X		
Pine vole				
Microtus pinetorum	X	X		
Muskrat				
Ondatra zibethicus	X	X		
S. bog lemming				
Synaptomys cooperi		X	X	
Muridae				
Norway rat				
Rattus norvegicus		X	X	
House mouse				
Mus musculus	X	X		
Zapodidae				
Meadow jumping mouse				
Zapus hudsonius		X	X	
Carnivora Canidae				
Coyote				
Canis latrans		X		
Red fox				
Vulpes vulpes		X	X	
Gray fox				
Urocyon cinereoargenteus		X	X	
Procyonidae				
Raccoon				
Procyon lotor		X	X	[illegible]
Mustelidae				
Long-tailed weasel				
Mustela frenata		X	X	

Table 7.3-2. Rare, Threatened, and Endangered Faunal Species Observed or Expected to Occur within the GREAT III Reach

Taxa	Status: Illinois	Status: MO	Status: Federal	Observed by [illegible]
MAMMALS				
Chiroptera				
Gray bat *Myotis grisescens*	E	E	E	
Indiana bat *Myotis sodalis*	E		E	
E. bigeared bat *Plecotus rafinesquii*		R		
Keen's bat *Myotis Keenii*		R		
Lagomorpha				
Swamp rabbit *Sylvilagus aquaticus*		R		
Rodentia				
Rice rat *Oryzomys palustris*	T			
Golden mouse *Ochrotomys nuttalli*	T			
Eastern woodrat *Neotoma floridana*	E			
Carnivora				
Long-tailed weasel *Mustela frenata*		R		
River otter *Lutra canadensis*	T	[illegible]		
Bobcat *Lynx rufus*	T		E	
BIRDS				
Pelecaniformes				
Double-crested cormorant *Phalacrocorax auritus*	E	E		[illegible]
Ciconiiformes				
Little blue heron *Florida caerulea*	E			
Snowy egret *Egretta thula*	E			

Table 7.3-2. Rare, Threatened, and Endangered Faunal Species Observed or Expected to Occur within the GREAT III Reach (Continued, Page 2 of 5)

Taxa	Status: Illinois	Status: MO	Status: Federal	Observed by ESE
BIRDS (Continued)				
Great egret				
Casmerodius albus egretta	E			X
Black-crowned night heron				
Nycticorax nycticorax	E			
American bittern				
Botaurus lentiginosus	E			
Falconiformes				
Mississippi kite				
Ictinia mississippiensis	E	R		X
Sharp-shinned hawk				
Accipter striatus	E	E		
Cooper's hawk				
Accipter cooperii	E	E		
Red-shouldered hawk				
Buteo lineatus	E	E		
Swainson's hawk				
Buteo swainsoni	E			
Bald Eagle				
Haliaeetus leucocephalus	E	R	E	
Marsh hawk				
Circus cyaneus	E	E		
Osprey				
Pandion haliaetus	E	E		X

Table 7.3-2. Rare, Threatened, and Endangered Faunal Species Observed or Expected to Occur within the GREAT III Reach (Continued, Page 3 of 5)

Taxa	Status: Illinois	Status: MO	Status: Federal	Observed by ESE
BIRDS (Continued)				
Peregrine falcon				
Falco peregrinus	E	E	E	
Galliformes				
Roughed grouse				
Bonasa umbellus		R		
Gruiformes				
King rail				
Rallus elegans	E	E		
Black rail				
Laterallus jamaicensis	E	U		
Yellow rail				
Coturnicops noveboracensis	E			
Purple gallinule				
Porphyrula martinica	E			
Charadriiformes				
Common gallinule				
Gallinula chloropus	E			
Piping plover				
Charadrius melodus	E			
Upland sandpiper				
Bartramia longicauda	E	R		
Wilson's phalarope				
Steganopus tricolor	E			
Forster's tern				
Sterna forsteri	E			
Common tern				
Sterna hirundo	E			
Least tern				
Sterna albifrons	E			
Black tern				
Chlidonias niger	E			
Strigiformes				
Long-eared owl				
Asio otus	E			

Table 7.3-2. Rare, Threatened, and Endangered Faunal Species Observed or Expected to Occur within the GREAT III Reach (Continued, Page 4 of 5)

Taxa	Status			Observed by ESE
	Illinois	MO	Federal	
BIRDS (Continued)				
Short-eared owl				
Asio flammeus	E			
Barn owl				
Tyto alba	E	E		
Passeriformes				
Brown creeper				
Certhia familiaris	E			
Bewick's wren				
Thryomanes bewickii	T			
Veery				
Catharus fuscescens	T			
Loggerhead Shrike				
Lanius ludovicianus	T			
Bachman's warbler				
Vermivora bachmanii	E			
Swainson's warbler				
Limnothlypis swainsonii	T	E		
Brewer's blackbird				
Euphagus cyanocephalus	T			
Henslow's sparrow				
Ammodramus henslowii	T	R		
Bachman's sparrow				
Aimophilia aestivalis		R		
HERPETOFAUNA				
Amphibia				
Caudata				
Four-toed salamander				
Hemidactylium scutatum		R		
Dusky salamander				
Desmognathus fuscus	E			
Silvery salamander				
Ambystoma platineum	E			

Table 7.3-2. Rare, Threatened, and Endangered Faunal Species Observed or Expected to Occur within the [illegible] Sites (Continued, Page 5 of 5)

Taxa	Status: Illinois	Status: MO	Status: Federal	Observed by ESE
HERPETOFAUNA (Continued)				
Salientia				
Wood frog				
Rana sylvatica		E		
Reptilia				
Testudines				
Alligator snapping turtle				
Macroclemys temmincki	T	R		
Illinois mud turtle				
Kinosternon flavescens spooneri	E	E		
Slider				
Pseudemys floridana x concinna	E			
Serpentes				
Eastern coachwhip snake				
Masticophis flagellum	T			
Great plains ratsnake				
Elaphe guttata	T			
Smooth green snake				
Opheodrys vernalis		R		
Dusty hognose snake				
Heterodon nasicus gloydi		R		
Green watersnake				
Nerodia cyclopion		R		
Eastern massasauga				
Sistrurus catenatus catenatus		R		

R = Rare—An animal in small numbers within the state, if the environment worsens may become endangered (Nordstrom et al., 1977).
E = Endangered—Prospects for survival within the state of [illegible] are in jeopardy.
T = Threatened—A breeding species which is in danger of becoming an endangered species in the near future ([illegible], 1979).
U = Uncommon within area of concern; potential to move into [illegible] category.

Sources: Nordstrom et al., 1977
Illinois Department of Conservation, 1979.
Illinois Natural Land Institute, 1981.

Table 7.3-3. Birds Sighted during Aquatic Sampling by ERE Personnel, Their Habitat Preferences, and Their Relative Abundance at Each Sampling Area

Species	Clarksville	Winfield	Ste. Genevieve	Cape Girardeau	Spring	Summer	Fall	Winter	Observed Habitat
	Occurrence at Site				Sampling Period				
PODICIPEDIDAE									
Pied-billed grebe *Podilymbus podiceps*	R							X	SB,S,L
PHALACROCORACIDAE									
Double-crested cormorant *Phalacrocorax auritus*			R					X	All habitats except tailwaters
ARDEIDAE									
Great blue heron *Ardea herodias*	A	A	O	O	X	X	X	X	All habitats
Cattle egret *Bubulcus ibis*	O			O	X	X			River banks, sloughs, side channel, and tailwaters (in flight)
Green heron *Butorides striatus*	O		O		X		X		All habitats except river banks and tailwaters
Great egret *Casmerodius albus*	C	C			X	X	X	X	All habitats except tailwaters
ANATIDAE									
Unidentified		C						X	
Canada goose *Branta canadensis*	C††	C††	C††		X		X	X	All habitats
Mallard *Anas platyrhynchos*	C	C	C		X	X	X	X	All habitats

Table 7.3-3. Birds Sighted during Aquatic Sampling by ESE Personnel, Their Habitat Preferences, and Their Relative Abundance at Each Sampling Area (Continued, Page 2 of 5)

Species	Occurrence at Site* Clarksville	Windfield	Ste. Genevieve	Cape Girardeau	Sampling Period† Spring	Summer	Fall	Winter	Observed Habitat††
Pintail *Anas acuta*		R						X	L
Green-winged teal *Anas crecca*	C††							X	L,S
Blue-winged teal *Anas discors*	C††				X				S,L
Teal (sp.)				X				X	S,L,M
Wood duck *Aix sponsa*	O	O	O		X			X	All habitats except main channel and its borders and [illegible]
FALCONIFORMES									
Turkey vulture *Cathartes aura*	C		C	C	X	X	X	X	River border, [illegible] sand bars and mud flats
Mississippi kite *Ictinia mississippiensis*				R	X				River border and main channel and its border
Red-tailed hawk *Buteo jamaicensis*				O				X	River banks, [illegible] sand bars and mud flats
Osprey *Pandion haliaetus*	R		R		X				All habitats [illegible] main channel and its borders, [illegible] and river, [illegible]

[illegible] Sampling Area (Continued, Page 3 of 5)

Species	Occurrence at Site*				Sampling Period†				Observed Habitats‡
	Clarksville	[illegible]	[illegible]	Cape Girardeau	Spring	Summer	Fall	Winter	
GALLIFORMES									
Bobwhite									
Colinus virginianus	R						X		Riverbanks
GRUIFORMES									
American coot									
Fulica americana	A	A	O		X			X	All habitats
CHARADRIIFORMES									
Killdeer									
Charadrius vociferus	C	C	C	C	X	X	X	X	D,I,RB
Herring gull									
Larus argentatus	C	C	C	C	X	X	X	X	S,M,T
Larus spp.	C	C	A	C	X	X	X	X	S,M,T
Common tern									
Sterna hirundo	C††	C††	C††		X				M,S,L
Caspian tern									
Sterna caspia			R		X				M,S,L
Black tern									
Chlidonias niger			A††		X				M,S,L
COLUMBIFORMES									
Rock dove									
Columba livia	A	A	A	A	X	X	X	X	RB
Mourning dove									
Zenaida macroura	C††	C††			X	X	X	X	I,L,RB

Table 7.3-3. Birds Sighted during Aquatic Sampling by ESE Personnel, Their Habitat Preferences, and Their Relative Abundance at Each Sampling Area (Continued, Page 4 of 5)

Species	Occurrence at Site*				Sampling Period†				Observed Habitat**
	Clarksville	Winfield	Ste. Genevieve	Cape Girardeau	Spring	Summer	Fall	Winter	
STRIGIFORMES									
Great horned owl *Bubo virginianus*	R				X				RB,I
Barred owl *Strix varia*		R			X				RB,I
[illegible]	A	A			X	X	X	X	RB,I
PASSERIFORMES									
Barn swallow *Hirundo rustica*	A††	A††	A††	A††	X	X			
Purple martin *Progne subis*			O††		X				
Blue jay *Cyanocitta cristata*	A	A	A	A	X	X	X	X	RB,I
Common crow *Corvus brachyrhynchos*	A	A	A	A	X	X	X	X	
Fish crow *Corvus ossifragus*			O		X				
Parus spp.	C	C			X	X	X		RB,I
Red-winged blackbird *Agelaius phoeniceus*	C	C			X	X			

Table 7.3-3. Birds Sighted during Aquatic Sampling by ESE Personnel, Their Habitat Preferences, and Their Relative Abundance at Each Sampling Area (Concluded, Page 3 of 3)

Species	Occurrence at Sites*				Sampling Period†				Observed Habitat**
	Clarksville	Winfield	Ste. Genevieve	Cape Girardeau	Spring	Summer	Fall	Winter	
Northern oriole *Icterus galbula*	O			O	X				RB,I
American Goldfinch *Carduelis tristis*		A††			X	X			RB,I,L

* A = Abundant—seen daily in large numbers.
C = Common—seen less than daily, but seen often.
O = Occasional—seen more than once, but not common.
R = Rare—only seen once or twice.

† Spring sampling session occurred April 23 to June 17, 1981; Summer—June 23 to July 23, 1981; Fall—August 18 to September 24, 1981; Winter—October 7 to December 10, 1981.

** RB = River bank.
S = Sloughs and side channels.
L = Floodplain lakes and ponds.
M = Main channel and borders.
D = Dikefields.
I = Islands.

†† Relative abundance during season noted.

*** Relative abundance in habitat noted.

Source: ESE, 1982.

Table 7.3-6. [illegible] GREAT III Reach (Continued)

Species	Pooled Section	Open Section	Observed
Ambystomatidae			
Spotted salamander	X		
Small-mouthed salamander	X	X	
E. tiger salamander	X	X	
Salamandridae			
Central newt			
Plethodontidae			
Dusky salamander		X	
Long-tailed salamander	X	X	
Cave salamander		X	
Dark-sided salamander	X	X	
Slimy salamander		X	
Zigzag salamander		X	
Proteidae			
Mudpuppy	X	X	
Sirenidae			
W. lesser siren	X	X	
Pelobatidae			
E. spadefoot			
Bufonidae			
American toad	X		
Dwarf American toad	X	X	
Fowler's toad	X		
Hylidae			
Blanchard's cricket frog	X	X	X
W. chorus frog	X	X	
Upland chorus frog	X		
Green tree frog			
W. bird-voiced treefrog		X	
N. Spring peeper	X	X	
E. gray treefrog	X		

Table 7.3-4. Herpetofauna Known or Expected to Occur within the GREAT III Reach (Continued, Page 2 of 4)

Species	Pooled Section	Open Section	Observed by [illegible]*
Ranidae			
N. crayfish frog	X	X	
Bullfrog	X	X	X
Greenfrog		X	
Pickerel frog	X	X	
N. leopard frog	X		
S. leopard frog	X	X	
E. wood frog		X	
Microphylidae			
E. narrow-mouthed toad		X	
Chelydridae			
Common snapping turtle	X	X	
Alligator snapping turtle	X	X	
Kinosternidae			
Stinkpot	X	X	
Testudinidae			
Mud turtle	X	X	
E. box turtle	X		
Three-toed turtle	X	X	
Ornate box turtle	X		
Mudland painted turtle	X	X	X
W. painted turtle	X	X	
Red-eared turtle	X	X	X
Slider	X	X	
False map turtle	X	X	X
Map turtle	X	X	
Mississippi map turtle	X	X	X
Trionychidae			
Smooth softshell	X	X	X
E. spiny softshell	X	X	X
Iquanidae			
N. fence lizard	X	X	

Table 7.3-4. Herpetofauna Known or Expected to Occur within GREAT III Reach (Continued, Page 3 of 4)

Species	Pooled Section	Open Section	Observed by ESE*
Anquidae			
W. slenderglass lizard	X	X	
Teiidae			
Six-lined racerunner	X	X	
Scincidae			
Ground skink	X	X	
Five-lined skink	X	X	
Broad-headed skink	X	X	
Colubridae			
Midwest worm snake	X	X	
Western worm snake	X		
Western mudsnake		X	
Northern ringneck snake	X	X	
Prairie ringneck snake	X	X	
Mississippi ringneck snake		X	
Eastern hognose snake		X	
Rough green snake	X	X	
Eastern yellow-bellied racer	X	X	
Eastern coachwhip snake		X	
Great Plains rat snake	X	X	
Black rat snake	X	X	
Bullsnake		X	
Black kingsnake		X	
Prairie kingsnake	X	X	X
Speckled kingsnake	X	X	
Eastern milk snake	X		
Red milk snake	X	X	
Northern flatheaded snake		X	
Western ribbon snake	X	X	
Eastern plains garter snake		X	
Eastern garter snake	X	X	
Western earth snake	X	X	
Midland brown snake	X	X	
Northern red-bellied snake		X	
Green watersnake		X	
Yellow-bellied snake		X	

8.0 GEAR AND STUDY EVALUATIONS

This section is primarily intended to provide a review of problems associated with sampling which would influence the quality and/or quantity of data collected. Secondarily, an evaluation of the gear and methods used and suggestions for alternative or additional methods and scope areas are provided.

8.1 STUDY PROBLEMS

The major continuing problem affecting the success of field sampling was the unusually high and unstable river levels present throughout most of the study period. The exception to this was part of the fall sampling period and the winter sampling period, which affected the study in several ways:

1. To varying degrees, the effectiveness of sampling gear, notably trawling, electrofishing, and trammel netting, was reduced by the stronger currents, turbulence and associated velocities and depths;
2. Frequent rapid rises in water level forced the delayed completion of sampling periods, especially spring and summer, thereby increasing the seasonal spread and decreasing data comparability within a sampling period; and
3. Equipment losses were increased and this resulted in increased data loss and downtime, especially for hoop netting efforts.

Tables 8-1 to 8-4 summarize the actual sampling conducted and data losses occurring during the study.

Table 8-1. Samples Collected at the Clarksville Site

Station	Electrofishing Sp	Electrofishing Su	Electrofishing Fa	Electrofishing Wi	Frame Netting Sp	Frame Netting Su	Frame Netting Fa	Frame Netting Wi	Hoop Netting Sp	Hoop Netting Su	Hoop Netting Fa	Hoop Netting Wi	Trammel Netting Sp	Trammel Netting Su	Trammel Netting Fa	Trammel Netting Wi	Gill Netting Sp	Gill Netting Su	Gill Netting Fa	Gill Netting Wi	Seining Sp	Seining Su	Seining Fa	Seining Wi	Trawling Sp	Trawling Su	Trawling Fa	Trawling Wi
1	2	2	2	2									2	2	2	X	X	X	X	1					3	3	3	3
2	2	2	2	2	3	3	3	3									1	1	1	2								
3	1	2	2	2	3	3	3	3									1	1	1	1								
4*	2	0	0	0	3	0	0	0									1	0	0	0								
5	2	2	2	2	3	3	3	3									1	1	1	1								
6	2	2	2	2					12	12	12	12	2	2	2	X	X	X	X	1								
7																									6	6	6	6
8	2	2	2	2					12	12	12	6	2	2	2	X	X	X	X	1								
9	2	2	2	2					12	12	12	12	2	2	2	X	X	X	X	1								
10	2	2	2	2					12	11	12	10	2	2	2	X	X	X	X	1								
11	1	2	2	2									2	2	2	X	X	X	X	1								
12	2	2	2	2																	2	2	2	1				
13	2	2	2	2																								

* Station 4 (Slough) samples missed due to inaccessibility after spring sampling period.

Sampling level of effort: Electroshocking (30 minutes), Frame Netting (net day), Hoop Netting (net day), Trammel Netting (10 minutes), Gill Netting (net day), Seining (1 hour), Trawling (10 minutes)

X = Samples not scheduled to be collected.
0 = Samples not collected.

Source: [illegible], 1982.

Table 8-2. Samples Collected at the Winfield Site

Station	Electrofishing				Frame Netting				Hoop Netting				Trammel Netting				Gill Netting				Seining				Trawling			
	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi
1	2	2	2	2									2	2	2	X	X	X	X	1					3	3	1	6
2	2	2	2	2	3	3	3	3									1	*	1	2								
3	1	2	2	2	3	3	3	3									1	1	1	1								
4†	2	0	0	0	3	3	3	3									1	1	1	0								
5	2	2	2	2	3	3	3	3									1	1	1	1								
6	2	2	2	2					12	12	12	12	2	2	2	X	X	X	1	1								
7																									6	6	6	6
8	2	2	2	0					12	12	12	12	2	2	2	X	X	X	X	1								
9	2	2	2	2					12	12	12	12	2	2	2	X	X	X	X	1								
10	2	2	2	2					12	12	12	12	2	2	2	X	X	X	X	1								
11	2	2	2	1									2	1	2	X	X	X	1	1								
12	2	2	2	2																	2	2	2	1				
13	2	2	2	2																								

* Gill Net lost or stolen.

† Station 4 (slough) not accessible to electroshocking during the summer.

Sampling level of effort: Electroshocking (30 minutes), Frame Netting (net day), Hoop Netting (net day), Trammel Netting (10 minutes), Gill Netting (net day), Seining (1 hour), Trawling (10 minutes)

X = Samples not scheduled to be collected.
0 = Samples not collected.

Source: ESE, 1982.

Table 8-3. Samples Collected at the Ste. Genevieve Site.

Station	Electroshocking*				Hoop Netting				Tunnel Netting				Gill Netting				Seining				Trawling			
	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi
7																					0	6	6	0
8	2	2	0	4	12	11	8	12	2	2	2	X	X	X	X	1								
9	2	2	0	4	12	11	12	12	2	2	2	X	X	X	X	1								
10	2	2	0	4	10	12	10	12	2	2	2	X	X	X	X	1								
11	2	2	0	4					2	2	0	X	X	X	X	1								
12	2	2	0	4													0	2	2	2				
13	2	2	0	4																				
14	0	0	0	1					0	4	0	X	X	X	X	1								
15	2	2	2	2	12	12	7	12	2	2	2	X	X	X	X	1								
16	2	2	0	4	10	12	12	12																

* Electroshocking collections not completed in the fall due to equipment malfunctions. Effort was made up, however, in the winter.

Sampling level of effort: Electroshocking (30 minutes), Frame Netting (net day), Hoop Netting (net day), Tunnel Netting (10 minutes), Gill Netting (net day), Seining (1 hour), Trawling (10 minutes)

X = Samples not scheduled to be collected.
0 = Samples not collected.

Source: ESE, 1982.

Table 8-4. Samples Collected at the Cape Girardeau Site.

Station	Electroshocking				Hoop Netting*				Trammel Netting				Gill Netting				Seining				Trawling			
	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi	Sp	Su	Fa	Wi
7									2	X	X	X									0	0	0	0
8	2	2	0	1	12	0	10	11	2	2	2	X	X	X	X	1								
9	2	2	0	2	9	0	9	11	2	2	2	X	X	X	X	1								
10	2	2	2	2	12	0	12	11	2	2	2	X	X	X	X	1								
11†	2	2	2	0					2	2	0	X	X	X	X	0								
12	2	2	0	2												2	2		2					
13	2	2	2	2																				
14	1	1	1	1					2	2	2	X	X	X	X	0								
15	2	2	2	2	7	0	10	12	2	2	2	X	X	X	X	0								
16†	2	2	2	0	12	0	12	12																

* Hoop net data for summer period lost during boating accident.

† Side channel and mouth of tributary not accessible to electroshocking in winter due to low river stage.

Sampling level of effort: Electroshocking (30 minutes), Frame Netting (net day), Hoop Netting (net day), Trammel Netting (10 minutes), Gill Netting (net day), Seining (1 hour), Trawling (10 minutes)

X = Samples not scheduled to be collected.
0 = Samples not collected.

Source: ESE, 1982.

8.2 METHODS AND GEAR EVALUATIONS AND ALTERNATIVES

FISH

In terms of overall collection effectiveness, the fishery methods utilized in this study are presented below in decreasing order:

1. Electrofishing,
2. Gill Net,
3. Hoop/Frame Nets,
4. Seine,
5. Otter trawl, and
6. Trammel Net.

This ranking is based partly upon the consistency and quantity of catch and partly upon the applicability of the method to a variety of habitats. Electrofishing, gill nets, frame nets, and hoop nets can be used in a variety of habitats and consistently produce good results. Seine usage is limited to relatively shallow water and principally collects the smaller species and individuals. Trawling is the primary method for collecting in deep water and met with limited success in this study. Trammel nets, as used in this study, were ineffective even though they were used in several habitats as per the scope.

Gear bias in terms of fish species and size classes collected was discussed in Section 6.2. In general, the smaller individuals and species were not well represented due to the limited amount of seining possible and the ineffectiveness of the trawling during the higher water stages. Lower water levels coupled with extensive seining and trawling would have added much information about the smaller fish species and size class composition.

The results of the chemofishing in the cutoff side channel accurately attest to the value of this method for determining the total fishery composition present in a habitat, especially when comparing the chemo-fishing data to those from other methods. Chemofishing would accurately

yield similarly valuable data from other habitats such as sloughs and river lakes. Main river habitats could also be sampled in this manner, although with noticeably less yield if currents and mixing are present. Although this method has application beyond the scope of this study, its use must be considered in light of the numbers of fish eliminated and problems with toxicants moving out of the study area.

In terms of specific considerations for nets used in future studies, several items could be noted. First, gill and trammel nets of 300 feet in length are difficult to deploy and fish, especially in strong currents and smaller backwater habitats. It might be more effective to halve the length and deploy additional nets. Second, larger mesh panels in some of the gill nets might increase the catch of large fish. The smaller mesh panels should, of course, be retained. Third, larger diameter hoop nets (with larger mesh) in combination with the smaller diameter nets used in this study should increase the range of size classes in the catch and perhaps the quantity of catch.

BENTHOS

The Ponar dredge was consistently effective in sampling the dominant soft substrates in each habitat sampled. Care was taken to ensure the collections of full grabs or additional grabs if incomplete grabs were obtained. The dredge is not a selective method as long as good penetration and retrieval of substrates are attained. Not sampling hard substrates resulted in a sizeable data gap for those habitats having hard substrates, notably revetted littoral and stone dike habitats.

ICHTHYOPLANKTON

The ichthyoplankton methodology employed during the study and resulting data were limited not so much by the technique or equipment used, but by the level of effort [illegible] for more details regarding ichthyoplankton sampling [illegible].

Tandem tows were made, using standard conical ichthyoplankton nets with each net metered for calculation of volume filtered, and the nets were towed well out of the zone of prop wash effect. Significant data limitations include the limited number of sampling habitats, the limited number of samples collected, the absence of night sampling and, most significantly, the lack of concentrated effort during the peak of larval abundance (April-July typically).

MUSSELS

As with the ichthyoplankton methodology, that for mussel collecting was limited primarily by the level of effort. Mussel brailing was conducted as per specifications provided by the USFWS.[10] The critical factors in brailing are that the brail hooks, but not the bar, drag on the bottom and that the brail is not towed too rapidly. Line tug and collection of bottom debris can confirm the former. In the case of the latter, standard procedures were to drift with the current or to use occasional motoring to maintain a constant low velocity.

8.3 SCOPE AND METHODOLOGY ALTERNATIVES

One aspect of the Scope of this study is that the contractor address limitations of the study scope and results and suggest alternative techniques or scope areas for future study considerations.

A major limitation of this study is that, given the extensive study area and the complexity of the aquatic systems involved, a one-year quarterly sampling effort at 4 sampling areas provides a minimal base from which to build evaluations of habitats and associated biota, especially in light of the unusual river conditions during this particular study period. Several years of similar or increased effort during variable hydrologic regimes (annual) would add immense validity to the resulting conclusions.

While considering the above, ESE remains confident that the data collected reflect baseline habitat and biotic features under the hydrologic regime experienced, and that conclusions made from the data collected must be considered in terms of the river conditions present at the time of sampling and of the techiques and level of effort utilized.

FISH

A factor significantly affecting the validity of comparing the fisheries data from habitat to habitat is that variable collection techniques were used, depending upon habitat type. This decreases the validity of comparing CPE values and species composition from habitat to habitat. The sampling of all habitats with electrofishing, gill net, and hoop or frame net would provide consistently greater quantity and quality of data, more comparable from habitat to habitat. The exception to this would, of course, be the main channel, where the trawl is the only feasible method proven to date. Trawling in other habitats such as main channel border, side channel, downstream end-of-island, navigation pool, and other habitats would enable direct comparisons to be made with main channel collections. Seining should be implemented in as many habitats as possible, especially during periods of low water.

BENTHOS

The benthic macroinvertebrate sampling program utilized in this study was basically oriented to soft sediments (silt, sand, clay, gravel). There are areas of hard substrates, notably wing dams and riprap, that would support organisms and assemblages not common in the soft sediments.

To fully characterize the benthos of each habitat type, both hard and soft substrates need to be sampled, as, and if, they occur in respective habitat types.

Rock basket type samplers would be effective in those habitats containing rock substrates, notably dike fields and revetted littoral zones. If only qualitative data were required, hand picking or sweep netting on the revetted littoral and rock dikes themselves would likely collect a majority of the taxa which would be collected by using artificial substrates.

Where soft substrates occur, the ponar dredge is an effective, easily used sampling tool. To control the variability factor of sediment (substrate) types within habitats and, if it is desired, to more closely correlate substrate type (i.e., grain size) with the associated benthic taxa, a preliminary sediment grain-size analysis would be advisable. Given this information, a number of dredge samples could then be taken in each sediment type identified. It might be necessary to increase the number of dredge samples taken, and this would be done using a species area curve or similar technique to determine the number of samples necessary to obtain a majority of the taxa present in each substrate class.

ICHTHYOPLANKTON

As indicated in the preceding section, the ichthyoplankton sampling program used in this study provides only cursory data regarding the

ichthyoplankton of the main river habitats. If one is to describe in detail the ichthyoplankton of the aquatic habitats of the [illegible] system, a greatly expanded program would be necessary. Such a program would include at least:

1. Weekly sampling (or more frequently if possible) in all habitats during the period April-July,
2. Some degree of night sampling as well as day sampling,
3. Vertically stratified sampling in deepwater (primarily main river) habitats, and
4. Transect sampling methods across the main river with at least three sampling points across.

This type of program would provide essential data on spawning periods, periods of peak larval drift of significant species, and the importance of each aquatic habitat for these early life stages.

The invertebrate component of the samples collected would provide useful data on the importance of invertebrate drift to the invertebrate community and would likely add some new taxa not collected by methods previously discussed.

MUSSELS

The brail (crowfoot) is the primary method used in a majority of mussel surveys. This can be augmented by diving and hand collecting and the use of some type of benthic sled or mussel dredge. For an intensive mussel survey, the ideal program would include some extensive brailing to identify and delineate mussel beds, followed by more intensive sampling with the brail and one of the alternate methods indicated above. During lower water stages, such a program should be particularly effective.

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